PETROLEUM PROCESSING

VOLUME 2, NUMBER 6 JUNE, 1947

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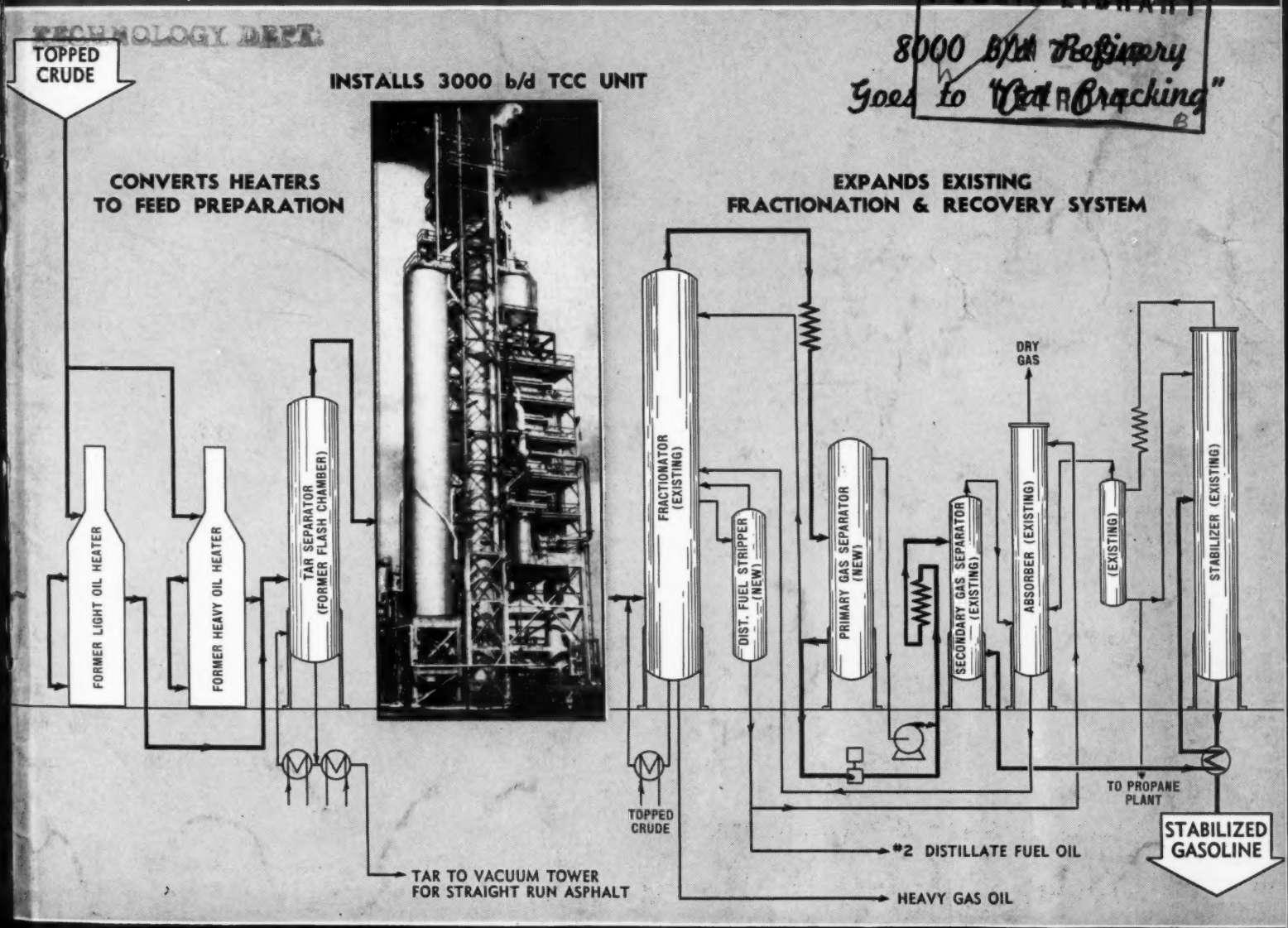
8000 B/d Refinery Goes to "Cat Cracking"



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SUMMARY OF ECONOMICS FOR VARIOUS REFINERY PROJECTS

Refinery Analysis No.	Crude Capacity BPCD	Gasoline BPCD	Distillate Fuels BPCD	Residual Fuel BPCD	ASTM Octane No.	TEL Ccs/Gal.	Crude Cost ¢/Gal.	By-Product Cost of Gasoline ¢/Gal.	Differential ¢/Gal.	Payout in Years
1	5,000	2,893	1,185	688	83.0	1.9	3.8	4.6	0.8	1.4
2	5,000	2,848	600	1,428	83.5	1.3	3.0	5.0	2.0	2.2
3	5,000	3,281	1,239	286	77.5	1.7	4.2	5.1	0.9	3.5
4	3,000	1,206	870	914	79.0	1.3	4.6	4.9	0.3	2.3
5	6,000	3,673	1,080	1,036	77.5	0.7	3.2	4.2	1.0	3.7
6	4,000	2,842	320	604	79.0	0.7	3.2	4.7	1.5	3.6
7	6,000	3,992	.....	1,566	82.5	0.9	3.0	5.1	2.1	2.9
8	4,000	2,610	400	753	78.0	0.5	3.1	4.6	1.5	2.9
9	12,000	7,787	1,800	1,602	81.0	1.5	2.8	4.0	1.2	1.1
10	5,330	3,812	.....	1,032	80.5	0.5	2.9	4.5	1.6	3.3
11	22,500	15,562	2,250	3,004	80.0	0.6	3.9	5.1	1.2	2.3
12	12,000	5,969	1,025	4,612	82.0	1.1	2.5	3.6	1.1	2.5
13	10,000	5,110	3,963	574	78.0	0.5	3.5	3.9	0.4	1.8
14	3,500	1,764	525	1,069	80.0	1.1	3.1	4.7	1.6	2.2
15	9,000	4,663	2,375	1,662	76.0	0.6	4.6	5.1	0.5	2.2
16	6,750	4,473	1,991	783	81.5	1.5	3.9	4.7	0.8	1.7

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PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
For Fuels, Lubricants and Petrochemicals
REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

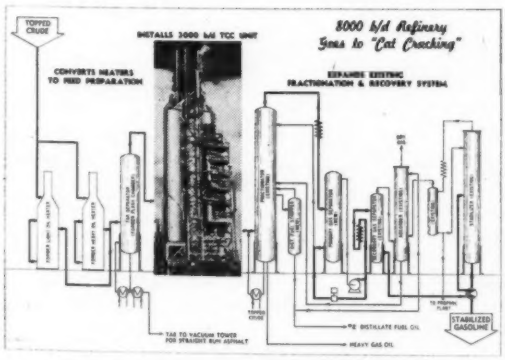
FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

STAFF FEATURES

STUDIES by an oil company to learn the cause of corrosion of tubing in condensate wells, as reported before a meeting of the National Assn. of Corrosion Engineers, developed information which may be important to the entire oil industry, and other industries also, in their fight against this "disease of metals". PETROLEUM PROCESSING's Equipment Editor, who was present at the meeting, later visited several steel companies to discuss this data with their metallurgists. Their comments as well as a review of the original paper and the discussion at the N.A.C.E. meeting, are presented in the article on pg. 405.

DURING the war a Michigan refiner studied for PAW the possibility of converting some of the smaller plants with thermal cracking to small-scale catalytic cracking, at a minimum of investment and using existing equipment to the utmost. The war ended before this program could be used, but this refiner has subsequently applied his ideas to his own 8000-b/d plant. The Engineering Editor visited the refinery, after the new unit had been running a few weeks, to learn the design features of the "cat" cracker installed and how the thermal equipment was fitted into the catalytic cracking operation. See pg. 411.

THIS MONTH'S COVER . . .


TOPPED CRUDE
INSTALLS 3000 b/d TCC UNIT
8000 b/d Refinery Goes to "Cat Cracking"
CONVERTS HEATERS TO FEED PREPARATION
EXPANDS EXISTING FRACTIONATION & RECOVERY SYSTEM
TO VACUUM TOWER FOR STRAIGHT RUN ASPHALT
TO INTERMEDIATE FUEL OIL
HEAVY GAS OIL
STABILIZED GASOLINE

At an investment cost of $200-250/bbl, Leonard Refineries, Inc., converted their 8000 b/d Alma (Mich.) refinery to catalytic cracking. As shown in the schematic diagram on the cover, changes included construction of a 3000 b/d TCC unit of improved design, and modifications of existing processing facilities.

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PETROLEUM PROCESSING
JUNE, 1947

New Theory for CORROSION OF CARBON STEEL

Findings by Oil Company that Crystal Structure of the Metal Is a Critical Factor Is Seen as an Important Development In Industry's Campaign Against Costly Losses from Corrosion

By WILLIAM C. UHL
Equipment Editor
PETROLEUM PROCESSING

THE METALLURGICAL structure of steel is a principal factor in the corrosion of the metal in oil industry service, according to a new theory advanced by technologists of Phillips Petroleum Co. Metallurgists of the steel companies are showing much interest in the devlopment. Indications are that it is an important advance in the oil companies' fight against corrosion.

The theory regards the structure of the carbide crystals in steels as the critical factor controlling corrosion. The oil company's work has shown that metal surface areas rich in lamellar pearlite (a crystalline form of carbide) are more corrosion resistant than those areas where the carbide structure is in spheroidized form. Conventional theory has been that corrosion in carbon steel resulted largely from electrochemical action induced by the environment between ferrite and carbide—the two dissimilar phases in the metal.

Improved analytical methods were used in the work in Phillips' metallurgical laboratories, including X-ray diffraction studies and photomicrographs of 2000 diameters magnification. The corrosion rate at the points were the carbide structure was in spheroidized form was shown to be often 10 to 100 times greater than elsewhere on the same piece of metal.

Spheroidization occurs, for illustration, when a small portion of tubing is heated, as during upsetting or welding operations and when this is not followed by normalizing or annealing to reconvert the carbide structure to the crystalline form.

The work by Phillips, both in the laboratory and in the field, was in the course of investigation of the cause of corrosion of oil well tubing in condensate wells. Corrosion here has been erratic in nature. It has, for example, appeared in only one of two side-by-side wells both producing from the same formation, which indicated that something more than external factors of corrosion were involved.

That the new theory, if upheld, will be a most important development in the oil industry's campaign against costly corrosion is widely recognized. As so far developed it applies only to carbon steel. The refining industry is a great user of carbon steels under conditions where its carbide structure might be in spheroidized form. Welding operations in refineries may be affected by this development because of localized heat effects. It is also believed that the same theory might apply in some alloy steels, which also are extensively employed in refineries.

The new theory was first presented in a paper, "Effect of Carbide Structure on Corrosion Resistance of Steel," by R. W. Manuel, Phillips Petroleum Co., and given during the Oil Industry Symposium at the Annual All-Corrosion Conference of the National Assn. of Corrosion Engineers in Chicago. April 7-10.

The work described in the paper was recognized as representing a significant step in the oil industry's fight against corrosion, according to authorities attending the conference. Metallurgists in the steel industry agree in general that the theory has considerable possibilities and that it merits continued studies for further support of certain phases wherein some questions and differences of opinion have arisen.

In his summary, Mr. Manuel stated that much field experience indicates that the carbide structure profoundly affects the corrosion resistance under conditions in which solid corrosion products form on the surface.

"Apparently, the unattacked cementite somehow affects the protectiveness of the other solids present," he said. "Whether this is some kind of anchoring action of the lamellae or a reinforcing action in the film itself is not clear. In any case, well-formed pearlite with lamellae which appear in the photomicrographs to be fairly long, straight, and continuous is definitely beneficial.

Spheroidization Not Beneficial

"Spheroidization of the pearlite removes this beneficial effect. Distortion of the lamellar pearlite structure by heating subsequent to its formation is detremental. Alloying elements which affect the lamellar structure may also sometimes be harmful. In quenched-and-tempered structures, the corrosion resistance becomes less, the greater the degree of tempering."

Mr. Manuel feels that the whole problem of carbide structure has been given too little attention in evaluating the corrosion resistance of steels. Phenomena previously dismissed as merely inexplicable vagaries of corrosion might be attributed to this factor by a careful re-examination of some past cases of corrosion in the light of the new theory.

"In future studies of the corrosion of

This special article is the first detailed discussion of the important development reported in the paper, "Effect of Carbide Structure on Corrosion Resistance of Steel", presented before the meeting of the National Association of Corrosion Engineers, in Chicago, April 7-10. The article also includes interviews with several metallurgical authorities among the steel companies.

steel, especially in oil well service, it should be given careful attention," he stated.

The most spectacular and freakish examples of corrosion failure in oil wells occur in the distillate wells—in the form of the so-called "ringworm" attack on upset ends of tubing. The fact that carbide structure has a critical effect had not been indicated by most previous investigators. The failures were ascribed principally to the galvanic action of the dissimilar metal structures in contact with each other, it was said.

Ringworm occurs near the upset in tubing which has not been normalized after forging. In the manufacture of such tubing, only the end is heated for forging the upset. This operation leaves a transition zone between the recrystallized metal of the heated end and the body of the tubing which was not heated to the critical transformation temperature range. There is a change in grain size from coarse to fine and back to coarse again in this zone.

"Ringworm" Laid to Spheroidization

"Microscopic examination of numerous specimens cut from corroded tubing has revealed that the ringworm occurs invariably in the area where the iron carbide, or cementite, is most extensively spheroidized," Mr. Manuel pointed out.

"This area is adjacent to the fine-grained zone on the side away from the upset end. In this area the original pearlitic structure has not been completely destroyed by recrystallization, but the cementite lamellae have broken up into shorter, thicker lamellae, and into spheroids. It has been found that the severely corroded band is usually rather abruptly bounded on either side by metal in which lamellar pearlite is predominant."

An example of ringworm corrosion in a length of 3-in. tubing in service in the Smackover Field in Arkansas is shown in Fig. 1. Although the groove was located in the usual ringworm zone, there was no local corrosion at other points on the circumference.

Microscopic examination of the specimen showed localized corrosion to be almost entirely in a longitudinal groove caused by rubbing of the sucker rod coupling against the tubing. The wall had been thinned 0.05 in. by the intensified corrosion resulting from the rubbing away of corrosion products. This had exposed the main body of spheroidized carbide structure in the wall, with the result that severe ringworm attack took place at this point.

Lamellar Pearlite Not Penetrated

Elsewhere, however, a thin layer of predominantly lamellar pearlite overlying the spheroidized zone was not penetrated, and no ringworm occurred.

The author points out that this indicates clearly how the carbide structure was a critical factor in this case. "It should be noted," he said, "that the significant feature of the fine-grained structure which previous investigations have shown to bound the ringworm zone on the upset side is not merely its grain size but the lamellar carbide structure.

"Usually this cannot be detected except at relatively high magnification, and sometimes the lamellar spacing is so close that even an oil-immersion microscope objective does not clearly resolve the structure at 2000 diameters."

It was also found that the hardness of the different zones varies significantly, with the spheroid zone always exhibiting the lowest and the fine-grained zone usually the highest readings. In this case, the original pearlite had a Rockwell hardness of B-82, the spheroid B-76, and the fine-grain B-85.

Some indication of why the carbide structure should affect the protective properties of the corrosion product film has been discovered through X-ray diffraction analysis and microscopic examination of these products.

Microscopic examination of the actual structure of the cementite in the film is made possible by the fact that the film, which is usually somewhat soft when parts are first removed from a well, hardens on drying. Sections of the steel can be cut, mounted, and polished, leaving the film intact.

It has been found that the unattacked cementite retains its original structure and dimensions in the film. Fig. 2 at A and B shows how the cementite appeared in a film on the surface of a steel with lamellar pearlite. The original structure is also shown, so that it can be seen how little affected the cementite was by the corrosive attack which completely destroyed the ferrite, or iron phase. Not only the ferrite grains, but also the ferrite between the lamellae was attacked.

Attack on Spheroidized Structure

The results of attack on a spheroidized carbide structure is shown in Fig. 2 at C and D. The spheroidized structure shown was in the ringworm zone of the same tubing in which the lamellar structure shown at A and B was found.

Localized corrosion of steel similar to ringworm attack in oil-well service has been produced in the laboratory by several methods, all of which have in common the formation of some kind of insoluble film on the surface. A method giving rapid and somewhat reproducible results employs a solution made up with sodium dichromate, concentrated sulfuric acid, and water in the proportions of 1 gm. to 2 ml. to 4 ml., respectively. At room temperatures this mixture does

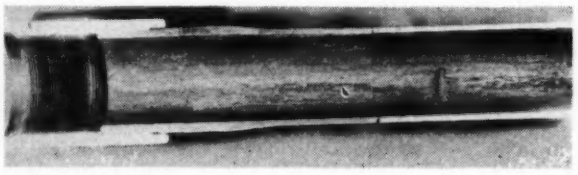

Fig. 1—Example of ringworm corrosion near the upset end of tubing

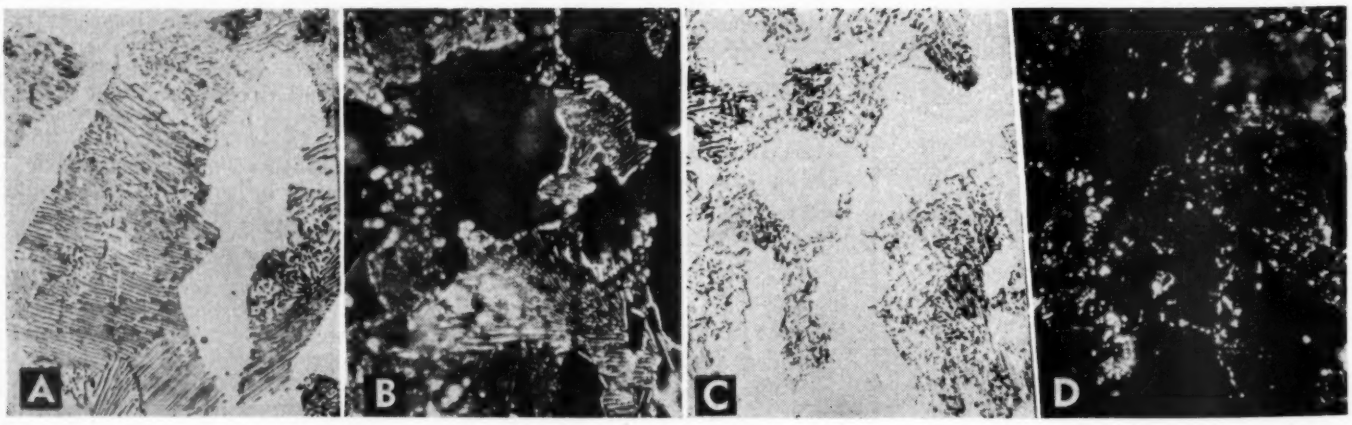

Fig. 2—Photomicrographs showing the difference between the two types of carbide structure in field samples. Original lamellar pearlite, A, has remained unattacked in the corrosion film. B. Note strong indication of plate-like crystals. Original spheroidized carbide. C, shows evidence of attack on surface. D. Note globular type of carbide

not violently attack steel, but at 175° F. and above, steel with a spheroidized carbide structure may be attacked at drastic rates as high as ⅛ in. penetration per hr.

Fig. 3 illustrates how spheroidized structure in steel is inherently more susceptible to attack than is pearlite. All three specimens were cut from the same ⅝ in. round steel bar, and all were originally ¼ in. thick. This fine-grained medium manganese steel (1.28 Mn, 0.37 C, 0.19 Ni) contained no significant amounts of other alloying elements.

One sample was normalized from 1600° F. and another was spheroidized at 1300° F for 5 hours. Both were then simultaneously exposed to the dichromate-sulfuric acid solution at about 180° F. for one-half hour. As can be seen, the spheroidized sample was well on the way to being completely destroyed while the normalized sample was only slightly attacked.

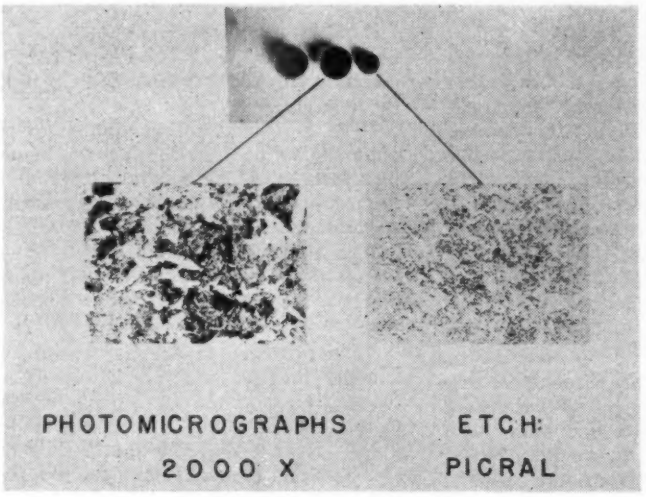

Fig. 3—Results of laboratory exposure of two samples of carbon steel to a sodium dichromate-sulfuric acid solution. Unexposed sample is at left, normalized pearlite at center, and spheroidized carbide at right. The spheroidized sample was completely destroyed in about one hour

Similar spheroidized samples have been completely destroyed in a little more than one hour, while normalized samples suffer only 0.02 in. penetration in the same time. The pearlite in the normalized metal consisted of very closely spaced lamellae.

"Carbide structure is significant not only in ringworm corrosion of upset tubing," Mr. Manuel stated, "but in other cases of oil-well corrosion." Recent examination of the flow line in a Gulf Coast field showed that most of the corrosion was localized. "In every case carbide structure of the steel appeared to be the most critical factor determining corrosion rate," he said.

The depth of corrosion in several fittings with quenched-and-tempered structures could not be correlated with composition very well, but a connection with structure could readily be detected. The greater the extent of tempering (the more coalescence of carbides into spheroids), the greater was the severity of corrosion.

Pipe Suffers Less than Fittings

The carbon steel pipe in the flow line itself had suffered less generally than the fittings, but in and near the welds and in certain lengths of pipe, local attack had occurred. The corroded areas at the welds were readily correlated with changes in carbide structure and in hardness.

Fig. 4 shows an example of corrosion in a welded bend. The microphotographs illustrate the sequence of structures, which resemble that found in tubing ringworm, going from pearlite to partially spheroidized pearlite to a new finer grain pearlite. The Rockwell B hardness varied through a 10-point range.

For alloy steels, the Phillips technologists have as yet found it rather difficult to correlate corrosive attack with carbide structure. However, it is believed that this is largely due to the inadequacies of metallographic techniques and limitations of the optical microsope rather than error in theory. Much work on this phase still needs to be done, it was stated. It is possible that use of the electron microscope may provide the correlation.

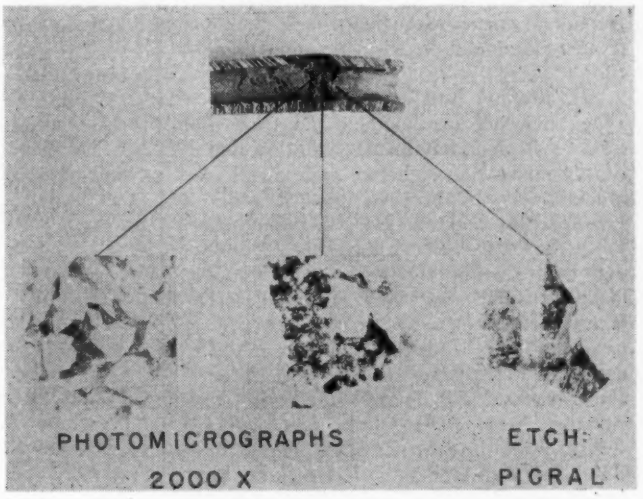

Fig. 4—Local corrosion in a welded bend in a distillate-well flow line. Corrosion groove at right of weld was confined to metal with partially spheroidized carbide structure. Metal at right with unaffected pearlitic structure was not severely corroded. Immediately adjacent the weld was a narrow band of fine-grained pearlite which also resisted attack

Alloys Need More Study

"The effect of carbide structure of normalized low-alloy steels needs more study," Mr. Manuel said. "There are indications that alloying elements may sometimes impair corrosion resistance by producing a deformed lamellar pearlite structure."

In the discussion period following the presentation of the paper in the corrosion engineers' meeting, Dr. Frank L. LaQue, International Nickel Co., pointed out that the effect described by Mr. Manuel apparently has so far escaped description by others largely because the corrosion product in the field is adherent while laboratory investigations on a speeded-up scale have been performed with violent acids which may never have given this film an opportunity to form.

The work described in the paper, Mr. LaQue said, is the foundation for a great advance in the solution of some very perplexing corrosion problems. International Nickel, he said, is going to do a lot of work on this and especially with reference to the alloy steels.

Mr. Manuel said, in answer to questions, that he did not believe corrosion of welded joints, especially of weld metal itself, is more due to turbulence at the joint than to carbide structure. Turbulence

may also be a factor, but in many cases the actual corrosion seems to have shown a nice consideration for the microstructure.

Mr. Manuel said in reply to Dr. A. Wachter, Shell Development Co., that it is not believed that initial scale, formed during fabrication or before exposure, has much to do with corrosive attack in wells. Dr. Wachter had pointed out the possibility that the effect of films formed during heat-treating should not be overlooked. He had suggested controlled tests where surfaces have been completely prepared so that mill scale and the like might not affect formation of a protective or non-protective film during later corrosive attack.

It is interesting to note that James T. Gow, Battelle Memorial Institute, in a paper presented during the General Industry Symposium at the N.A.C.E. Conference, indicated somewhat similar opinions with regard to carbide structure in high-temperature, iron-nickel-chromium alloys.

". . . Micro-structural features other than that of the matrix structure are also of importance," he said, "especially the carbide phase, the amount of it present, distribution, continuity, and stability. . .

". . . The relative resistance of metals to high temperature oxidation corrosion is known to be determined by their ability to form a protective scale layer. . .".

Might Explain Refinery Corrosion

That the new theory might explain unusual cases of corrosion in the oil refineries is not too far-fetched. A large percentage of equipment in modern petroleum processing units is fabricated from carbon steels. Many companies use carbon steel, if only to cut down on the high costs of initial investments, replacing parts later with more expensive alloys as needed.

Some refineries use tubing and piping that is already normalized. However, the reason for normalizing is to prevent failures due to insufficient stress relieving. No data has as yet been taken to study the effects of such normalizing upon possible corrosive attack.

Normalizing following upsetting is not a common procedure to all tubing manufacturers. Some do it simply as a matter of service to the customer. Others will do it if the purchaser requests and is willing to pay the additional charges.

In order to secure the reaction of some of the leading steel manufacturers, the technical editors of PETROLEUM PROCESSING have discussed this new theory with a number of engineers and metallurgists in that field.

Normalizing might not be sufficient protection; rather it might eventually be necessary to require full annealing, according to Mr. C. L. Clark, research metallurgical engineer, Timken Roller Bearing Co., Steel and Tube Division.

Annealing could be done except in the case of welded pipe in the field, where it would present considerable difficulty. The alternative of substituting older methods of fastening pipe for welding would of course be making progress backward. The answer would ultimately be in a rapid inexpensive process for treating pipe in the field.

Mr. Clark raised a pertinent question as to the economics and cost factors involved. "Would the oil industry be willing to pay for the added life expectancy and service of the tubing?" he asked.

Mr. G. A. Reinhardt, director of research, Youngstown Sheet and Tube Co., agrees with Mr. Manuel that more rapid corrosion occurs in the ferrite. However, he wonders whether the answer isn't merely a case of relative solubilities of the various structures in the corrosive medium. He also questions the possibilities of spheroidization occurring under the conditions cited. Ordinarily it would take several hours of holding at temperatures below the critical range. His experience does not indicate that a spheroidized structure would form merely by cooling in air following the upsetting operations. The photomicrographs, however, would seem to support the fact that such spheroidization has been and is occurring.

Ringworm in Condenser Tubing

Babcock & Wilcox Tube Co. has found evidence of ringworm corrosion in welded medium-carbon steel tubing such as on condensers and heat exchangers, where stress-relieving was not done following welding, according to Dr. H. D. Newell, chief metallurgist.

He feels that the Phillips engineers have produced substantial evidence of the carbide structure differences and their effect on corrosion in the steels in question. The theory would not seem to have a direct application to the alloy steels because of their different mechanism for corrosion resistance, Mr. Newell believes.

The present concepts as to corrosion causes should explain satisfactorily the cases cited in Mr. Manuel's paper, according to Mr. W. E. Coleman, assistant metallurgist, Youngstown Works, Republic Steel Co.

"The best evidence presented (in the paper) to support the thesis is the laboratory tests in which a marked difference in corrosion rate in favor of the annealed specimen occurred," he said.

The attempts to explain the causes of corrosion in service on the same basis, however, are not convincing, for several reasons, Mr. Coleman stated.

"The existence of a spheroidized and lamellar pearlitic structure in closely associated areas of the same piece of commercial steel tubing is not a common phenomenon. Also, the author does not appear to have considered the possible effects of grain size differentials or the effects of high-temperature oxide films in localized corrosion phenomena associated with differential heating effects."

He also pointed out that typical ringworm attack occurs in upset tubing made from nearly carbon-free iron (0.02 C, 0.14 Mn.), in which no trace of any carbide structure could be detected under the microscope. More data will be required in order to establish this as a corrosion mechanism of general commercial significance, he believes.

While the corrosion theory presented in Mr. Manuel's paper is new to them, metallurgists at the American Steel & Wire Co., agreed to its definite importance. They point out that while the science of corrosion prevention has made tremendous strides in the field of atmospheric and aqueous attack, it is only in its infancy with respect to chemical failures.

In fairness to those steel industry technologists who have been relatively critical of the theory, it must be emphasized that X-ray diffraction apparatus and photomicrographic studies in the magnification range of 2000 diameters are not commonly used tools of the trade.

As analytical methods are improved through the development of new and better instruments, it is only natural that theses regarded today as revolutionary will become accepted principles.

Metallurgical Terms

Annealing—A heating and subsequent cooling operation, implying usually, slow cooling under controlled conditions in the furnace, sometimes in a special atmosphere. Among its purposes are (1) to remove stresses, (2) to alter physical properties, and (3) to produce definite microstructures.

Normalizing—Heating to about 100 F. above the critical range and subsequent cooling to below that range in still air at ordinary temperatures. Its purpose is generally the same as that of annealing, but it is lower in cost because of careful control involved in annealing.

Carbide—A constituent of steel, chemically Fe_3C, also called cementite.

Ferrite—Iron constituent of steel.

Lamellar Pearlite—An aggregate of ferrite and carbide in a plate-like crystalline form.

Spheroidized Carbide—A lamellar pearlite which has coalesced to form tiny globules, usually occurring as a result of holding for a prolonged period below the critical temperature.

TOMORROW

...IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Chlorinated paraffins are finding quantity markets.**
- **Petroleum synthesis to dominate alcohol field.**
- **Octane ratings of agriculture motor fuels reported.**
- **Fleet tests made on long-life synthetic lubricants**
- **New book fills gap in plastics information.**

Chlorinated Paraffins Are Finding Quantity Markets

AS MENTIONED last month, considerable valuable data are contained in the "Facts and Figures" releases of the Bureau of the Census. In this connection, it might be interesting to look at the half-year figures released for chlorinated paraffins, defined as "those chlorinated derivatives of paraffin wax containing 20% or more of chlorine by weight."(1)

During the period cited, total allocations amounted to 63,194,000 pounds, of which 938,000 pounds went to "direct military" uses, 25,000 pounds were exported, and 62,231,000 pounds (98.5% of allocations) went to the following "other uses": Flame-proofing, 54,669,000 pounds; extreme pressure lubricants, 6,010,000 pounds; cutting and drawing oils, 1,416,000 pounds; and miscellaneous uses and small orders, 136,000 pounds. It might be mentioned that most of the "direct military" uses were probably also concerned with "impregnating compositions based on chlorinated paraffin for treating canvas duck, camouflage nets and strips, and other textile materials to make them flame resistant, waterproof, and mildewproof."(2)

It is highly probable that the chlorinated paraffins will find increased usage in the future, for other known uses include plasticizers for plastics, resins, and synthetic rubber; corrosion resistant paint compositions; can linings for food containers; "hot melt coatings, adhesives, printing and lithographic inks, and paper coatings;"(2) fireproof paints; and insecticides.

"The chlorinated paraffins and particularly such products as chlorinated kerosine are undoubtedly of considerable interest as raw materials for chemical synthesis, but research in this field is only beginning. The use of cholrinated kerosine as a raw material for synthetic detergents and wetting agents is one outstanding example of this application, and undoubtedly others will be developed as research work in this field continues."(2)

(1) Anon., Chlorinated Paraffins in the War Program, Department of Commerce, Bureau of the Census "Facts for Industry" Series 6-8-59, Washington, 1947.

(2) Scheer, W. E., *Chemical Industries* 60, No. 2, 203 (1944), "Properties and Uses of Chlorinated Paraffins."

Petroleum Synthesis To Dominate Alcohol Field

INDUSTRIAL alcohol played an important role during the war both as an uneconomic but necessary raw material for butadiene synthesis and as a solvent used in many important processes. Peak year consumption reached about 600,000,000 gal., largely produced from agricultural materials but only to a minor extent from blackstrap molasses, the chief prewar source.

To the petroleum industry, ethyl alcohol has long been of considerable interest, first as an antifreeze for filling station sale and then as a "chemical from petroleum." Emphasis on the first point is waning, since price potentialities and comparative properties point to a losing battle with methanol and ethylene glycol antifreezes. However, every factor seems to point to the growing dominance of the petroleum industry as a supplier of both raw materials (for use by chemical companies) and of the substance itself.

According to Dr. Robert S. Aries,(3) blackstrap molasses will be used only for marginal production of alcohol by the end of the next decade. High costs, better sugar recovery, and demand for other uses will all contribute to lessen the importance of a material which petroleum ethylene had already driven to the wall before the recent war. Supplies of molasses, now insufficient, may eventually become abundant at the end of the sugar shortage, when invert molasses will again become available, but Dr. Aries doubts if the alcohol industry will ever again depend upon it as the chief raw material. Neither does he see assurance that economics will permit serious competition from alcohol derived from wood wastes or waste sulfite liquors, and he dismisses the subject of grain alcohol with the slight attention that it warrants on an economic basis.

(3) Aries, R. S., "The Changing Industrial Alcohol Picture," Paper presented before the Division of Sugar Chemistry of the American Chemical Society, Atlantic City, April 17, 1947.

Turning to the subject of petroleum as a raw material, Dr. Aries states that 70,000,000 gal. per year are already being produced from ethylene and that many additional plants are in prospect.

Even more significant as regards the future, Dr. Aries notes that the three natural gas synthesis plants now planned or under construction will *each* produce about 8,000,000 - 10,000,000 gal. of alcohol per year as a by-product. These quantities will almost certainly be separated from co-produced chemicals in order to obtain by-product acetic acid and acetaldehyde, whose production in this manner, incidentally, will make inroads on the normal use of alcohol as a raw material for their synthesis. Moreover, "a single plant to make it directly (by a variant of the Synthine process) can satisfy our entire prewar demand for ethyl alcohol." Other chemicals would also be produced, along with fuel oil as a by-product.

In remarking on the subject of power alcohol, Dr. Aries believes that this fuel will probably never be economic except in the odd chance that the petroleum industry may find itself with surplus Synthine-derived alcohol with a market price below 10c per gal., at which time it might use it for blending with petroleum fuels. Moreover, it might be noted that alcohol becomes a competitive raw material for butadiene synthesis at such levels.

Alcohol is now selling on the open market for over 80c per gal., compared with a prewar range of 20-25c, but this figure will only be maintained until sufficient petroleum alcohol plants can come into production, for Dr. Aries states that costs from ethylene are below 15c per gal. even at present economic levels. In the next decade, demand for alcohol is expected to rise to over 200,000,000 gal. per year, chiefly for chemical use, and it certainly appears that the petroleum industry will provide by far the major portion of this quantity.

Octane of Agricultural Motor Fuels Reported

UNDER the present Synthetic Liquid Fuels Act, research on agricultural fuels has been delegated to the U. S. Department of Agriculture, and, while the petroleum industry may have its doubts as to the economic justification for this research, there is no doubt as to the value of some of the fundamental information being released.

As previously mentioned in this feature, and many times elsewhere, power alcohol from agricultural materials has

no economic chance of competing with gasoline, although Synthine-derived, by-product alcohol may someday be employed as a blending agent. In any case, it is interesting to note that a resurvey[4] has been made of the octane ratings of agricultural fuels and that some new information has been obtained.

Ethyl alcohol, as a motor fuel, "belongs to the class of sensitive fuels" which have considerable higher Research (F-2) octane numbers than Motor Method (F-1) numbers. "In general the F-1 ratings of ethanol and its blends, which have F-2 octane numbers in the neighborhood of 90, are above 100 and the F-1 rating of ethanol itself, according to Puckett, is equal to iso-octane plus 1.4 ml. TEL. According to the authors, the F-2 rating of ethyl alcohol is 90.7, a value below those reported by several other authors.

"Aniline is the most effective compound for raising the (F-2) octane number of ethanol (20% yields a fuel equivalent to iso-octane plus 0.04 ml. TEL). The effectiveness of higher aromatic amines, such as toluidine and xylidine, is much lower; and lengthening of the side chain, as in n-butyl aniline, actually lowers the octane number of ethanol. Addition of 25% of isoparaffins, such as neohexane or S-3 reference fuel, causes a greater increase in octane number than a similar addition of benzene, although the octane number of benzene is 100+ (extrapolated value), whereas those of the former are 95.1 and 99.7, respectively.

"Tetraethyllead depresses the octane number of pure ethanol as well as that of some of the higher alcohols. . . . . However, it appears that the action of moderate amounts of lead and of ethanol is independent in blends containing up to about 25% ethanol; for higher ethanol contents the difference is relatively small unless the gasoline is highly leaded. . . . . The presence of 4 ml. of TEL per gallon definitely lowers the ratings of blends which contain more than 20% ethanol. Methanol has zero lead susceptibility, whereas *tert*-butanol shows a high blending lead susceptibility."

Various oxygenated compounds blend with ethanol roughly in relation to their per cent of the blend and their pure octane numbers; acetone is particularly effective, as is 20-25% of water (which raises the F-2 octane of the blend to 99.3).

"Pro-knock compounds, such as *tert*-butyl hydroperoxide and iso-amyl nitrite, used as ignition accelerators, lower the rating of ethanol much less than that of 90 octane number reference gasoline. . . . .

"Alcohols, like benzene and other aromatics, are fuels which vary greatly in antiknock quality under lean mixture and rich mixture conditions. Thus, the F-3 test for aviation fuels (lean mixture rating) rates ethanol only 84.2; . . . . under certain conditions in the rich-mixture region, relatively high outputs may be obtained with pure ethanol." Injection of ethyl alcohol and alcohol-water blends are also briefly discussed, but without presentation of new data.

The authors make extensive comparisons of their data with reported values, and their paper is timely in that it summarizes the value of agricultural motor fuels without regard to their economics.

(4) Elder, C. F., Truby, F. R., and Wiebe, R., *Industrial and Engineering Chemistry* 39, No. 4, 508 (1947), "Octane Ratings of Agricultural Motor Fuels."

Synthetic Lubricants Fleet Tests on Longlife

THE petroleum and automotive industries, and the public as well, have been paying close attention to news of the polyalkylene-glycol-derivative synthetic motor oils which were announced last year by the Carbide and Carbon Chemicals Corp. For this reason, considerable interest has been aroused by a recent paper[5] which deals with fleet tests of these lubricants, largely in commercial vehicles.

Space does not permit details of the tests involved, but the "tentative conclusions" are of definite significance. "In general, test results to date seem to indicate the following possible advantages in the use of synthetic oil as compared to detergent oils:

"1. Ability to cover a greater range of temperature with a single grade of oil.

"2. Somewhat reduced carbon formation, particularly on valve stems. Such carbon as is formed is of softer texture. Some reduction in frequency of valve and carbon jobs. Slightly freer rings.

"3. It appears that oil change mileages can at least be doubled, in any given class (commercial vehicle, tractor, earth borer, etc.) of service, with no loss in oil economy, and improved engine cleanliness.

"Tests to date indicate that the following factors are at least comparable, using either synthetic or detergent oil in any given class of service: (1) oil economy, (2) gasoline economy, and (3) overall maintenance costs."

Tests on passenger cars were not sufficiently extensive to warrant comment in this paper, but almost fabulous drain periods have been reported elsewhere. Increased public attention to such lubricants is entirely likely, and it is also quite likely that petroleum chemists are engaged in concentrated research to produce oils of similar characteristics; research on synthetic lubricants has recently been proceeding at an accelerated pace in any case. As regards the Carbide and Carbon products, it will be interesting to see whether quantity production can be achieved and whether prices can be reduced. Since ethylene from petroleum is the probable raw material, it will also be enlightening to observe whether a petroleum chemical derivative can compete on a large scale with a refined petroleum fraction.

(5) Wilson, D. K., "Fleet Tests of Synthetic Lubricants," Paper presented at the SAE National Transportation Meeting, Chicago, April 16-18, 1947.

New Book Fills Gap In Plastics Information

IN CONSEQUENCE of their growing importance in industrial uses, plastics are today receiving much attention in the technical and popular press. Some of this information is duplicatory in nature; some of it represents highly specialized attention to restricted phases of the subject; and almost all of it is usually so diffusely distributed that the situation literally demands the preparation of survey books.

Some such books have long been available, but most of these attempt to cover the subject in all of its ramifications and succeed only in outlining the important phases. Others are devoted to specific phases—data handbooks, economics, etc. One or two describe the plastics industry in details that the layman can understand, hence are not strictly part of the technical literature.

Over a decade ago, Carleton Ellis, noting this need, prepared a two-volume compendium on "The Chemistry of Synthetic Resins." Since that time, the "vast fund of information . . . has swollen to enormous proportions," so great that "the need for a book . . . . which would correlate scientific information in this domain (plastics) with industrial practice" became very evident. For all these reasons, a book[6] has recently been published which should serve an important purpose in the plastics field, both as a textbook for study and as a reference book for information.

Space does not permit details of the contents of this book, which covers the subject material by material, following a description of history, raw materials, basic plastics chemistry, and plastics fabrication. An excellent index renders the book highly usable.

Plastics are of growing importance to the petroleum industry, as witnessed by a recent PETROLEUM PROCESSING article[7]. For this reason, the availablity of information in an authoritative form is of considerable significance and, when this data is also presented in the language of a scholar and experienced writer, it can hardly be ignored by one who is seeking the information contained.

(6) Wakeman, Reginald L., "The Chemistry of Commercial Plastics," Reinhold Publishing Corp. (New York), 1947.

(7) Weil, B. H., PETROLEUM PROCESSING 2, No. 3, 215 (1947), "Plastics Makers Look to Petroleum Chemicals for Raw Materials."

8000 b/d Refinery Converts Thermal Unit To Catalytic Cracking for $200-250/Bbl.

How one small independent refiner converted his existing thermal facilities to catalytic cracking—how he tied in a 3000 b/d TCC unit with those facilities—and how he kept costs down to his economic level—all told in this exclusive PETROLEUM PROCESSING story, the first detailed account of this new installation at Leonard Refineries, Inc., Alma, Mich.

By WILLIAM F. BLAND
Engineering Editor
PETROLEUM PROCESSING

CATALYTIC cracking for the small independent refiner became an economic reality last March when Leonard Refineries, Inc., successfully put on stream its new 3000 b/d TCC unit at Alma, Mich.

The new small-scale "cat cracker" was achieved at an exceedingly low investment cost—in the neighborhood of $200-250 per bbl. of charge capacity. This figure, within the economic means of many small operators, includes the revamping and tieing in of existing thermal facilities to provide the necessary feed preparation and fractionation-recovery systems for the newly installed catalytic cracking unit. (Cover illustration shows how existing equipment was converted to the catalytic cracking operation.)

Operation of the new unit began March 18, only six months after ground was broken. Actual construction of the TCC part of the unit, engineered by Houdry Process Corp. and erected by its subsidiary, Catalytic Construction Co., took less than five months. Since going on stream the unit has been running continuously, frequently at better than design capacity, and without major operating difficulties.

Leonard Is Typical Small Refinery

Leonard Refineries, Inc., is a typical small independent refining business. The company was organized in 1936, and at that time purchased the newly-erected 3000 b/d plant of the now defunct Acme Refinery Corp. at Alma. In 1939 additional facilities were purchased from McClanahan Refining Co. at St. Louis, Mich., just a few miles away. Today the company's operations are rated 8000 b/d crude charging capacity.

Leonard's small size, however, doesn't deter it from having big-business ideas about how it should operate. It has a modern, well-equipped office building that compares more than favorably with many bigger companies' facilities. It maintains its own research and development staff, and is now enlarging its research laboratory.

Reid Brazell, Leonard's president and general manager, sees no reason why the small refiner can't be just as progressive and forward looking in his operations as the larger companies. "The small refiners have to sell their products in general competition," he said, "and they must be prepared to make just as good or better products as they will encounter in marketing fields."

"Cat Cracking" Considered 3 Years Ago

It was over three years ago that Brazell began thinking seriously about how the small refiner could add catalytic cracking to his operations. At that time neither he nor anyone else knew how much longer the war would last or how much higher the demands for 100-octane would go. But he did know how long it would take to get new "avgas" plants built and operating.

A canvass showed there were around 80 small refineries in this country with thermal cracking units. Brazell and others on PAW recognized the possibilities for greatly increasing aviation gasoline production if their existing facilities could be converted to catalytic cracking and that it could be done much more quickly and at less expense than through building new plants, even if materials were available for entirely new plants.

Brazell was looking ahead also. He knew that just as soon as the war ended most of the aviation gasoline plants with their big catalytic cracking units would stop making 100-octane gasoline. He also knew that it wouldn't take their operators very long to switch to the production of high quality motor fuel. On top of this he knew that the aviation gasoline plants were either government-owned or in the hands of the major refining companies except in a very few instances. He realized the acuteness of the problem the small refiners would face at the end of hostilities in producing motor fuels to meet the competition of the plants with catalytic cracking units.

PAW had approved in February, 1945, the program for converting some of the thermal cracking plants to catalytic cracking operations. However, before it had gone very far with any conversion plans, hostilities ended and the wartime need for additional catalytic cracking facilities fell by the wayside. Brazell was convinced, however, that he wanted catalytic refining for his own refinery and his first job, when he could drop his wartime duties, was to plan how the Alma refinery could be converted to a catalytic cracking operation.

Cost of Previous Units Too High

All previous installations had cost millions of dollars—even the smallest one. "With such astronomical cost figures staring us in the eye," Brazell recollected, "it looked like an impossible situation at the start."

But he took his problem to various engineering firms and told them what he wanted—"a 3000 b/d 'cat cracker', installed complete and ready to put on-stream in our existing thermal plant for a 'reasonable' investment."

Some engineers were cold on the proposition at the start. "The plant can't be built for the figure you have in mind", was among the objections brought up. But Brazell isn't the type to be easily discouraged. He kept on pouring over blue prints and studying what type of catalytic operation would best fit in with the existing equipment at his own refinery.

The TCC process was eventually selected as the one to concentrate on. Pilot

Engineering details of the design and construction of the small-scale TCC unit at the Alma, Mich., refinery of Leonard Refineries, Inc., will appear in a later issue of Petroleum Processing.

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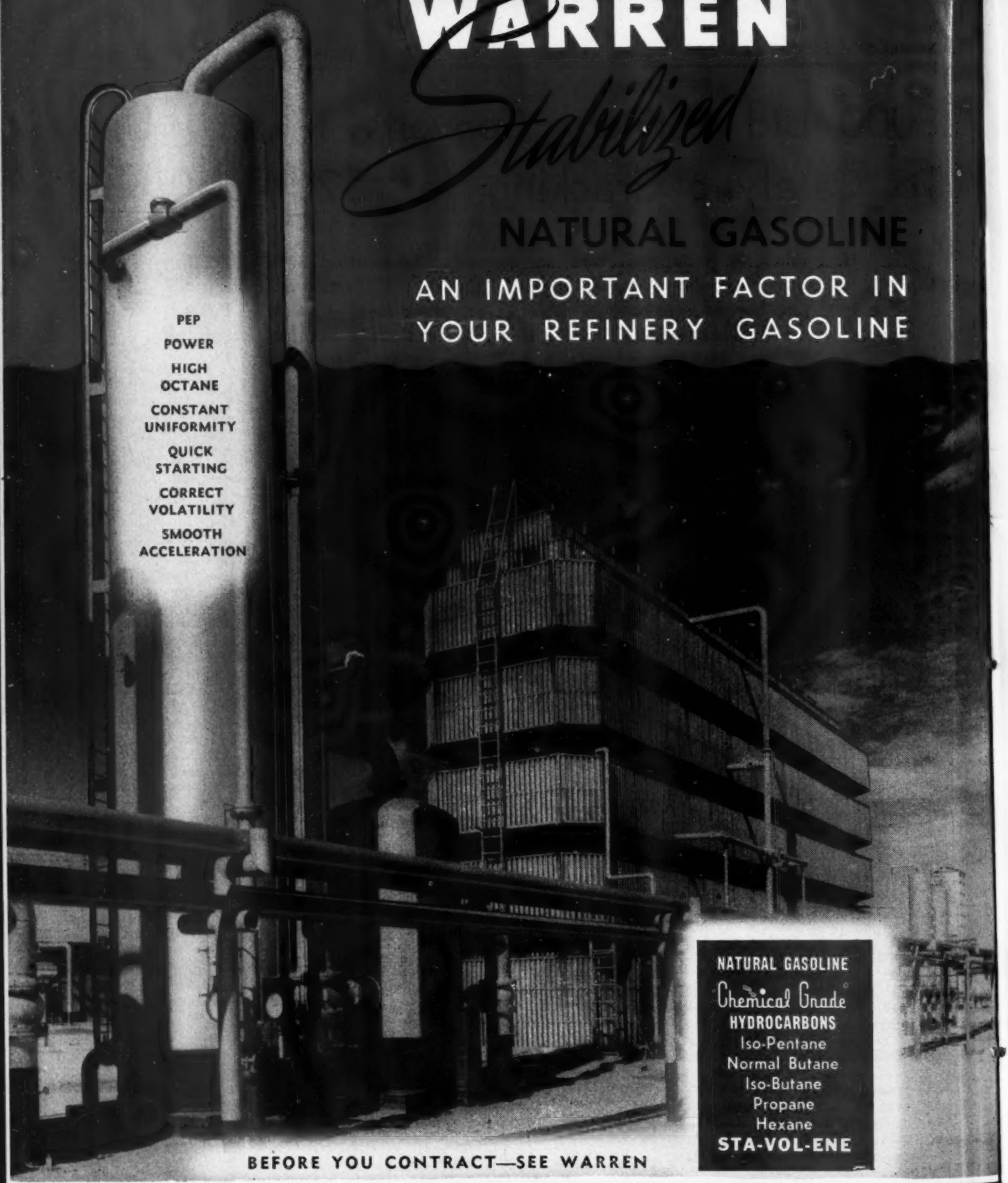

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plant operations showed that less coke and less gas were produced with it when operating on Michigan crude of the type Leonard usually runs. In addition, it had flexibility. If some emergency required the shutting down of the unit for a few minutes or even longer, the catalyst would remain static and the unit could be started up again with little trouble.

As finally engineered by Houdry, the 3000 b/d Leonard TCC unit is very similar in its principal design features to the larger TCC units. Investment cost, however, has been kept down by employing many design simplifications. Overall height has been substantially reduced. Previous units were around 240 ft. high; the Leonard installation is only 183 ft. to the very top of the airplane warning beacon, and the actual supporting structure is only 157 ft. high.

The reactor and catalyst feed hopper are an integral unit and entirely self-supporting, with the space between them, as shown in Fig. 1, being utilized for catalyst storage. The kiln is also self-supporting, the structure surrounding it being only for access and auxiliary equipment.

One important simplification is an integral catalyst elevator design employing a split bucket and requiring only one elevator for both spent and regenerated catalyst. The usual passenger elevator has been eliminated entirely.

What to Convert?

Once the TCC process had been selected as the one to use, the next step was determining what of Leonard's equipment could be effectively converted.

In 1945 Leonard was still operating two plants. Its main one, at Alma, had a crude capacity of 3000 b/d and included an 1800 b/d 2-coil Dubbs heavy oil thermal cracking unit. The crude unit, however, was then being enlarged to 8000 b/d. The St. Louis plant, with a 4000 b/d crude unit, had a 1500 b/d reformer.

Leonard's engineers saw immediately that either the Dubbs plant or the reformer would adapt itself to the contemplated conversion, providing the necessary feed preparation and fractionation-recovery facilities.

On the surface it looked as though the reformer was less economical to operate than the Dubbs unit, and that it was the one to be included in any conversion plans. On the other hand, if the reformer were converted to the new catalytic cracking operation that was contemplated, then both the Dubbs thermal cracker and the new catalytic unit would require the same basic type of charge stock—and would compete with one another for it. Further, the refinery would be left without any way of upgrading its straight-run gasoline, a product of relatively low octane rating. It could have been blended with the catalytic cracked product, but with a serious loss in the quality of the latter.

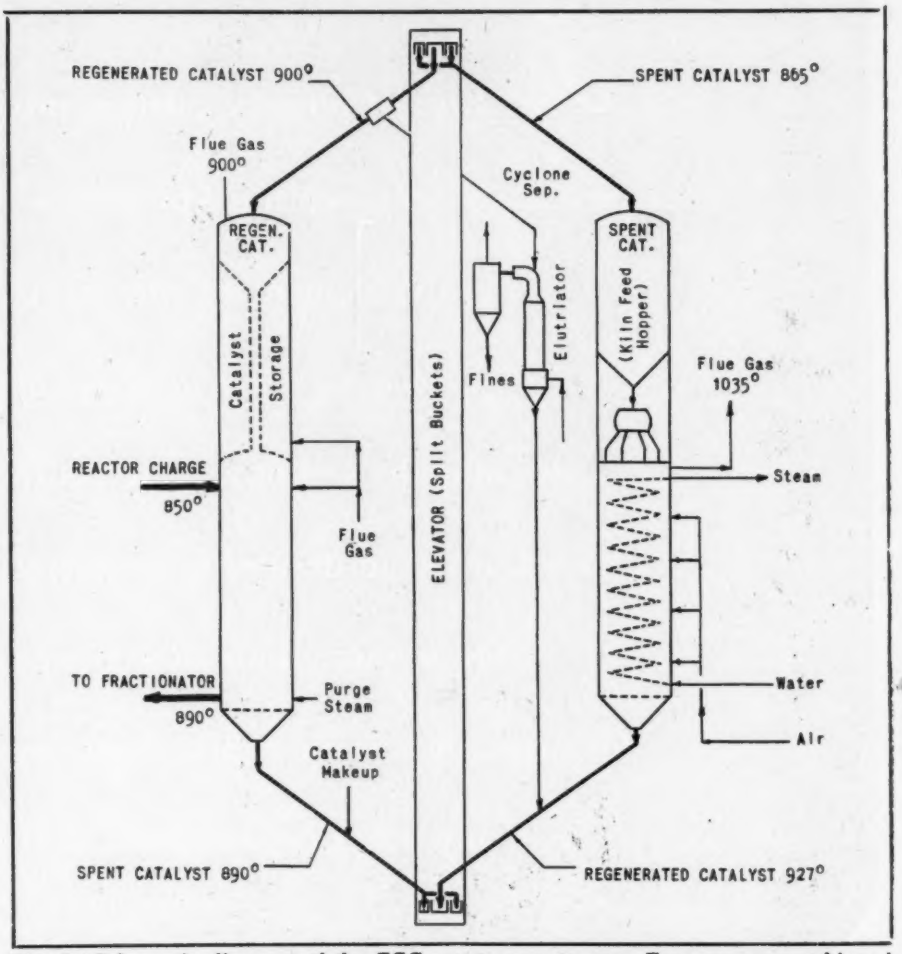

Fig. 1—Schematic diagram of the TCC reactor-regenerator. Economy was achieved by reducing the overall height of the structure, eliminating the usual passenger elevator, and using a single catalyst elevator with split buckets

Reforming Could Be Less Severe

Another consideration was that the reformer operation could be made more economical by cutting down on the severity, with subsequent greater yields and less depreciation of the equipment. Such operation would be possible with catalytic cracking available to produce quality fuel to meet competition.

Events have since proved the correctness of that point. Operating temperatures have been reduced from 1070 to 1030° F., while yields (on straight run gasoline charge) have jumped from 65 to 75%. Octane number, as expected, has dropped from 72 (MM, clear) to 61, but the low-quality fuel, which leads up to 76 with 3 cc. of TEL, can be blended with the high-quality catalytic cracked product.

After looking at all angles, it became apparent that the best solution was to convert the Dubbs unit, which was done.

Leonard, incidentally, took advantage of the pending remodeling job to consolidate all its refining operations in one spot. As soon as the decision to convert the Dubbs unit and retain the reformer was made, the latter unit was dismantled and moved from the St. Louis plant to Alma, where it was erected and put back into service. The balance of the St. Louis plant and equipment was subsequently sold to Michigan Chemical Corp.

Previous Operation of Dubbs Unit

The Dubbs unit was built in 1936, and had remained essentially unchanged since then, with the exception of the addition in 1944 of a centrifugal hot oil pump, which increased its capacity from 1000 to 1800 b/d.

As it had been operating prior to conversion, it consisted of a fractionating tower, two furnaces (light oil and heavy oil), reaction chamber, flash chamber, distillate receiver, absorber, stabilizer and auxiliary equipment.

Flow through the unit is shown in Fig. 2. Reduced crude from the skimming plant was pumped at atmospheric temperature into the lower section of the fractionator, and served to quench the incoming vapors from the flash chamber. Bottoms from the fractionator went to the heavy oil heater, while a side cut went to the light oil heater.

From the heaters both streams went to the reaction or soaking chamber, at

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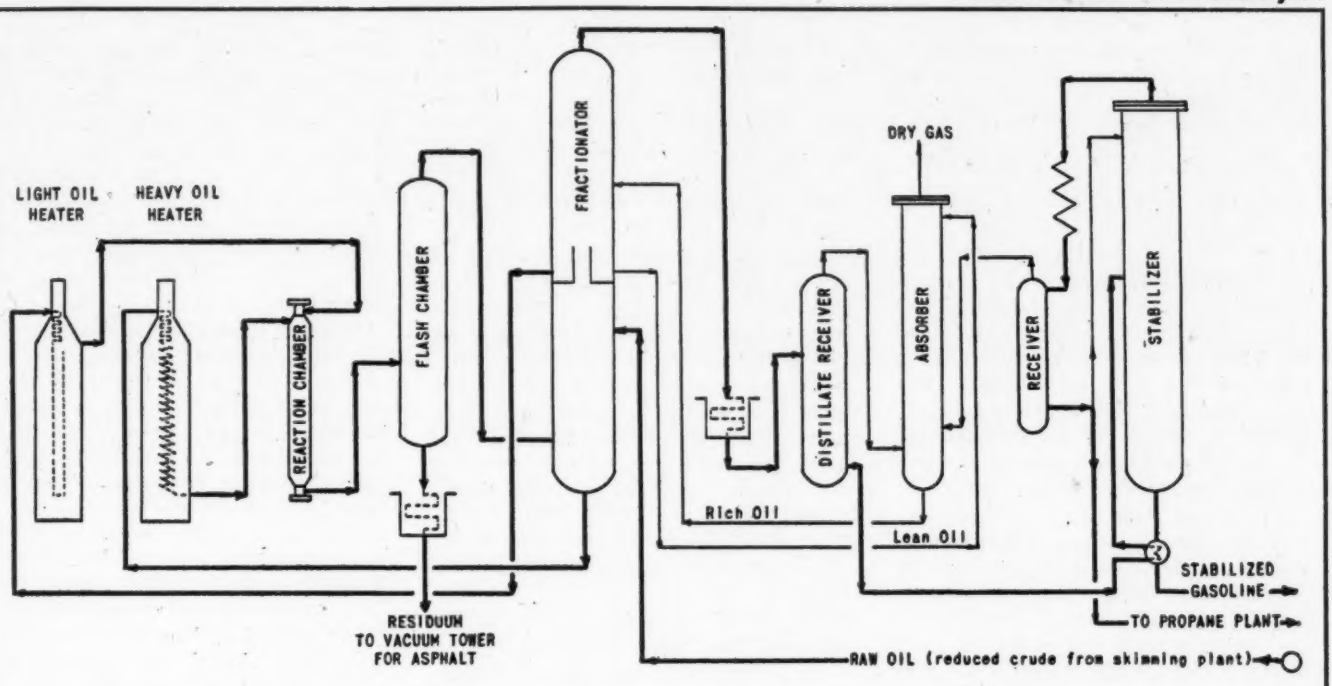


Fig. 2—Flow diagram of the Dubbs unit at Leonard before being converted to the TCC operation

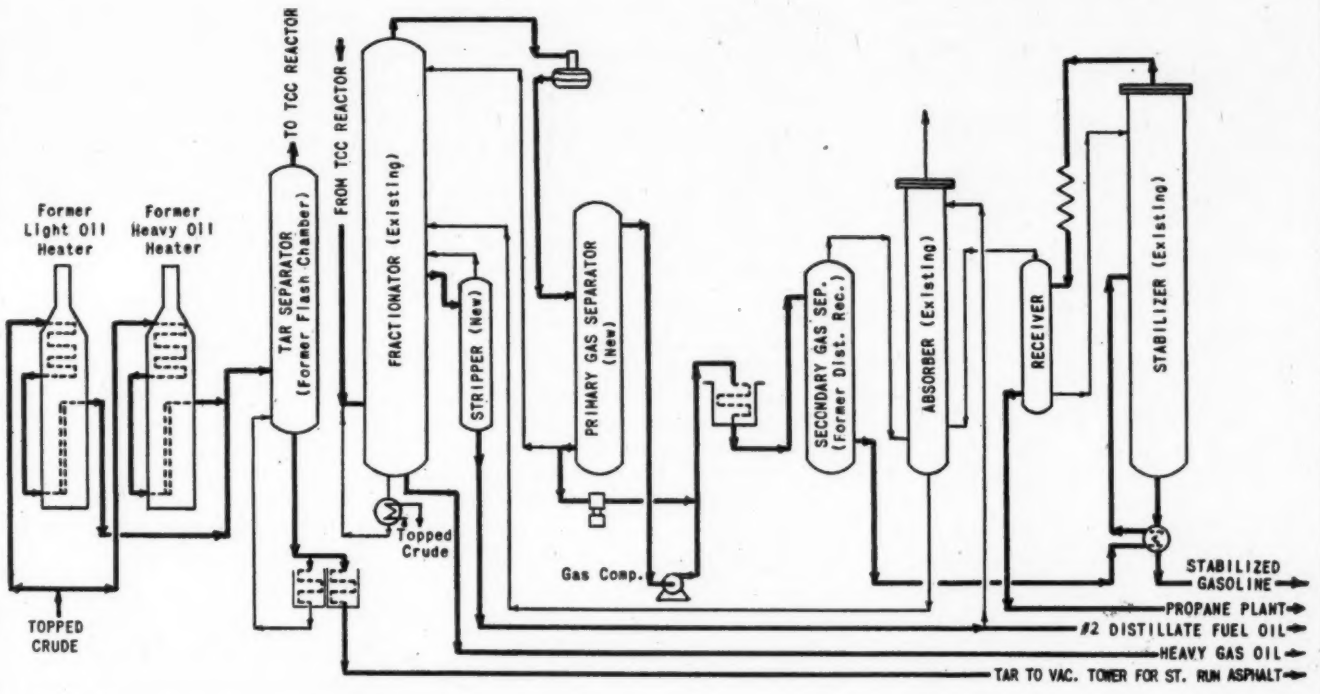


Fig. 3—New flow diagram showing how the old equipment was utilized and tied in with the new TCC unit, with only a few additional pieces of equipment being added to provide greater capacity

900° F. and 300 psi pressure, and then to the flash chamber.

Bottoms from the flash chamber were sent to the asphalt vacuum tower. Overhead vapors went to the fractionator, where, as previously pointed out, they were quenched by the incoming raw crude.

Overhead from the fractionator was run through a condenser and into a distillate receiver. Unstabilized gasoline was drawn off the bottom and sent to the stabilizer. Overhead gases went to the absorber, where they were contacted by lean oil, a side cut from the fractionator, the resultant rich oil being returned to the fractionator.

Capacity Increased to 3000 b/d

Leonard found that the Dubbs equipment, with only a few unique design changes, could be rearranged to handle 3000 b/d in conjunction with the TCC unit.

The changes were relatively simple. As shown in Fig. 3 they consisted essentially of using the two furnaces and the flash chamber as the feed preparation section, and enlarging the fractionation-recovery system by adding a new cooler, a primary gas separator, and a gas compressor. The rest of the recovery section was usable as it was, with the addition

of a side stream stripper to recover catalytic No. 2 distillate fuel oil. The reaction chamber is not utilized at all in the conversion setup.

Flow Through Heaters Changed

Considerable revamping was done on the arrangement of flow through the heaters. As previously operated, the light oil furnace consisted of a 48-tube convection section and a 50-tube radiant section, with flow being through the convection section and then through the radiant section from top to bottom. The heavy oil heater had the same tube arrangement, except that the flow through the radiant section was down one bank of tubes and up the other.

As revised, both furnaces have the same flow pattern and operate entirely in parallel. Only the top 36 tubes in the convection sections are used for oil heating, the remaining 12 now being used as a steam superheater section in each furnace. In the radiant section the flow is in two parallel streams in each furnace, in at the bottom and out at the top. This change was necessary to prevent too great a pressure drop, since the old reaction chamber, which operated at 300 psi, has been eliminated, and oil vapors now leave the furnace at only 12 psi.

The flash chamber was converted to a tar separator and all internals removed. To accommodate the increased throughput and low pressure drop allowed, new inlet and outlet nozzles and lines were provided, sizes as follows:

	Old In.	New In.
Inlet line	5	8
Inlet nozzle	6	8
Overhead nozzle and line	8	14
Bottoms nozzle and line	2½	4

Instead of going directly to the fractionator from the flash chamber, as in the previous flow, the overhead now serves as charge stock for the TCC reactor.

Fractionator Gets New Trays

As previously operated, the fractionator included 16 trays and 10 side by side pans, plus a light oil reservoir pan. The tower, according to Leonard's Technical Director, John Pfarr, would have served very well in the new operation with exactly the same setup of trays and pans, removing only the light oil reservoir pan.

New trays had been ordered, however, before the decision was made to convert the thermal operation to catalytic. Since the new trays were therefore available when the conversion was being made and would in all probability have to be installed within a few years anyway, it was decided to remove all the old trays and pans, rearrange the tray spacing, and put in the 16 new trays.

The 8-in. inlet and outlet lines on the fractionator were changed to 18-in., to accommodate the increased throughput, and another 2-in. heavy gas oil draw-off was added at the bottom. Two new side connections were added—a 4-in. nozzle for feed to the distillate fuel oil stripper and a 6-in. vapor return line from the stripper. Reflux connections and the rich oil return line from the absorber remain unchanged, but all other nozzles have been blanked off.

A new barometric direct-contact condenser has been added to receive the overhead from the fractionating tower, which now flows to a new primary gas separator. A new centrifugal gas compressor has been added to take the overhead gas from the primary separator and compress it to 75 psi, after which it and the liquid bottoms from the primary separator are pumped through the old cooler and into the former distillate receiver, now the secondary gas separator. From that point on the recovery section remains basically unchanged.

On average operation, the new catalytic unit produces about a 50% yield of 10 lb. RVP gasoline, with specifications as follows:

End point, ° F.	400
Gravity, ° API	56
Octane, motor method, clear	78
+ 3 cc. TEL	86
Octane, research method, clear	90
+ 3 cc. TEL	97

In addition, the unit produces about 33% of catalytic No. 2 distillate fuel oil (600° E.P.), 8% of heavy catalytic gas oil (90% boiling at 730° F), 7% B-B cut (now going to the Polymer Corp. for synthetic rubber), and 6% dry gas (all burned in the plant). These yield figures are all based on volume. In addition, coke deposited on the catalyst produces 18,000 lbs./hr. of 290-lb. steam.

Leonard's TCC unit is extremely flexible in its operations, much more so than originally anticipated. Practically everything from very heavy asphaltic crude oil to light gas oil has been charged to it.

Raw crude oil, in fact, has already been charged to the unit on two separate occasions. The first time it was done as an experiment to see what would happen. The second time it was a necessity; Leonard's crude unit was down for emergency repairs, and the supply of charge stock for the TCC unit feed preparation section was running short. It was a question of either running on raw crude or shutting the catalytic cracker down too. Because of the straight run material, a greater quantity of overhead was taken from the flash chamber and product quality fell a few octane points, but other than that the unit operated normally.

One night during a bad thunder storm, the refinery had over 12 power interruptions, some lasting as long as 15 minutes. They didn't even cause a major fluctuation in the unit's operation. When the power is off, of course, the catalyst elevator stops. If the interruption is more than momentary the valves controlling feed of both spent and regenerated catatyst into the elevator automatically close, too, holding the catalyst in a static position, ready for circulation as soon as possible. With catalyst circulation thus stopped it is only necessary to bypass the charge stock around the reactor and recycle it back to the feed preparation section.

When the power again comes on and the catalyst starts circulating, it is only necessary to cease recycling the charge stock and immediately pick up operations where they were let off. All electric motor-driven pumps have steam standbys so that pumping operations can be continued.

"The small refiner needs an installation which has extreme flexibility," in Brazell's opinion. "He generally has only one of each type of unit in his plant —and if anything happens to any one of them it can shut down his entire operations—and cut off his profits—unless he has flexibility."

Catalytic Cracking Now Costs Less

Small-scale cracking units of the type Leonard has are now down in price to the point where they can be built for less than new thermal cracking facilities. A Leonard-type installation can be made today for around $200-250 per bbl. of charge capacity, converting existing thermal facilities. That figure includes installing the catalytic cracking unit complete, as well as converting and tieing in existing facilities.

A complete new thermal unit would cost in the neighborhood of $300 per bbl., Brazell claims.

The cost of Leonard's installation was in line with the $200-250/bbl. figure. If you like to juggle figures, however, you can come out with a much lower conversion cost. The present catalytic cracking capacity of the unit is 3000 b/d, 1200 bbls. more than the previous thermal capacity of 1800 b/d. "If we hadn't converted to catalytic cracking," says Brazell, "we would have had to increase our thermal facilities anyway, so on that basis we can write off a good portion of the cost against the increased capacity—which greatly reduces the amount properly charged to plant conversion.

"Our plant was in an advantageous position in that respect, however, since our overall plant facilities were top-heavy with respect to our thermal cracking capacity."

Brazell thinks the small refiner should get busy and install catalytic cracking facilities right now—rather than waiting to see what else might develop.

"Today," he says, "the small operator can borrow the money he needs. He's in a prosperous business, his product is selling well, and his financial standing is good. He's a desirable credit risk."

Plant-Built Equipment Grades Catalyst On California Polymerization Unit

A PLANT-designed and built catalyst grading machine and auxiliary handling drums for returning the graded material to the catalyst polymerization unit towers enable a crew of ten men to grade and replace the catalyst in one column in about 4½ hrs. at the Norwalk (Calif.) refinery of Wilshire Oil Co., Inc. The previous method, screening by hand, took twice as long and resulted in considerable catalyst loss by breakage.

Following burning off coke in the tower by conventional methods, catalyst occasionally must be removed to separate fines from normal size pellets so as to maintain the required efficiency. In addition, it is necessary that the pellets be handled with a minimum attrition loss.

The improved technique consists essentially of (1) dumping catalyst bed from tower, (2) removal of broken fire brick by grading through large mesh screen, (3) removal of fines in grading machines and (4) returning normal pellets to tower.

As shown in the photographs, the grading machine is constructed as a "two-story" unit with a platform on the top deck surrounded by safety rails. Two operators pour ungraded catalyst from drums, mechanically elevated, into a hopper having a capacity of approximately two drums.

The hopper is built with an inverted, truncated pyramid base, and is fitted with a slide-covered opening which is manually operated to control the flow of catalyst upon the screens. These screens are all built, regardless of mesh size, on uniform frames which fit into the shaker assembly. Thus any screen may be used to separate broken brick or to separate fines from the normal size pellets.

The shaker table is built with an inclination of approximately 40° from the horizontal. It provides the minimum slant needed to cause catalyst to flow by gravity gradually over the screen to the outlet without excessive tumbling.

The screen shaker table is mounted on hanger supports having connecting rods to a cam type drive shaft driven by an air motor.

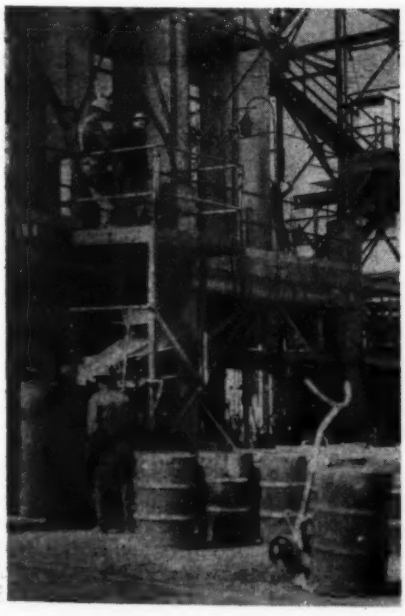
A sloping pan, built into the unit below the shaker screen, is tilted in the opposite direction to receive the fines and direct them into an open drum below the outlet. The entire unit is built into a structural steel frame and mounted on wheels so that it can be moved intact from one catalyst tower to another without disassembling.

Screened catalyst pellets are collected in special drums, about five ft. high, constructed of steel tubing about 20 in. in diameter. These drums have open tops and bails attached to rings welded on opposite sides. Crane cable is connected to the bail with a clevis secured by a bolt and nut.

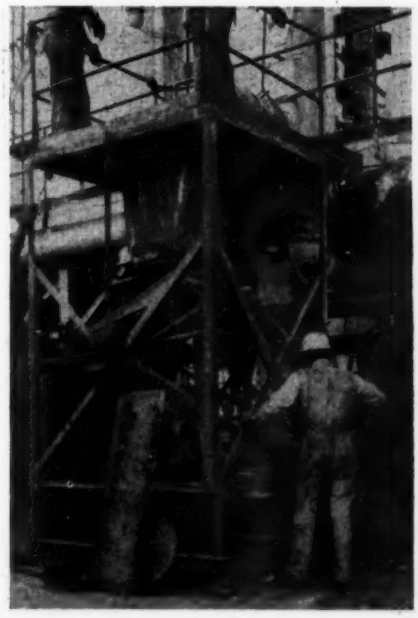
The bottom of the drum is closed with a hinged lid secured by a latch which can be tripped after the loaded drum has been taken to the top of the tower and lowered inside. A locking pin insures safe closure of the dumping mechanism.

In replacing graded pellets, the dumping-drum is lowered right to the top of the catalyst bed so as to permit the pellets to empty gently without attrition loss.

Three air motor-driven winches are employed for the various lifting operations. One lifts drums of ungraded catalyst to the top of the grading machine for loading the hopper. Another lifts the filled special dumping drums to the top of the polymerization unit, and a third shifts the filled drum from the end of the extending boom back over the opening of the column.

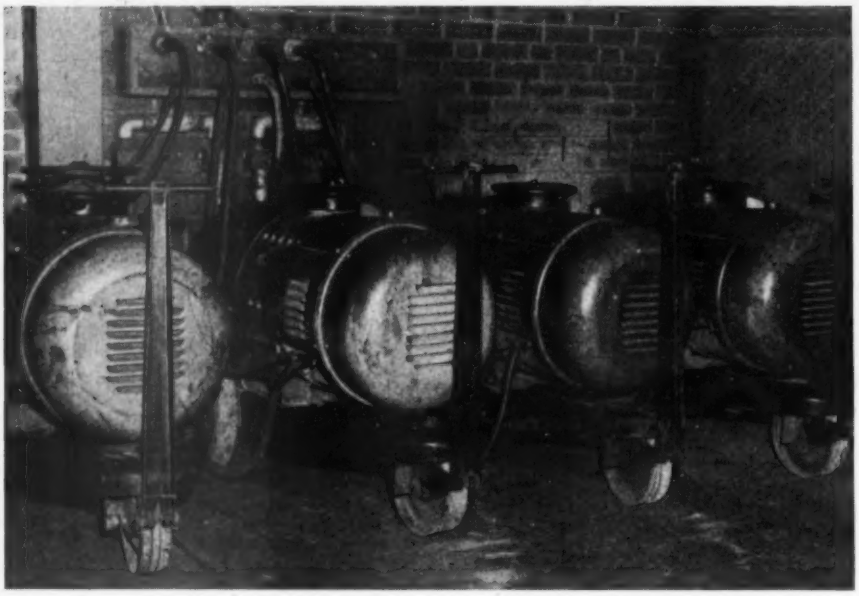


Left, catalyst grading machine in place at base of polymerization towers. Special dumping drum is at left alongside the grader, receiving normal size pellets from the screen. Below, end view of dumping drum showing hinged lid at bottom. Right, close-up view of grader; fines are being collected in drum at right. A large mesh screen is leaning against the grader



Distribution System for Welding Current Helps to Keep Floor Clear of Cables

By VERNON STARR, Welding Shop Foreman
Socony-Vacuum Oil Co., Inc., Lubrite Division, East St. Louis



A manifold connects the welding machines to distribution system. Color coding of cables and fittings assures operator of correct hook-up with proper machine

One of two overhead power outlets in Socony-Vacuum's Lubrite Division welding shop. Cable length to electrode is kept to a minimum

ONE OF the worst problems about a welding shop is keeping the floor clear of electrode cables, which snake about everywhere if several welders are working simultaneously. Frequently they are damaged by heavy objects falling on them, or they cause workmen to trip. Also, it is often inconvenient to move the generator close to the work without using long lengths of cable.

Socony-Vacuum's Lubrite Division has solved this problem by using a welding current distribution system carried in a large metal conduit, which permits the machines to be permanently located close to the shop walls out of the way. The "hot" connection is made from a distribution-main outlet closest to the work.

The ground cable connection is made from the work to any one of several metal pipes forming a checker work pattern of 6-ft. squares, located in the floor just slightly below grade and which, in turn, are connected to the machines. Thus the wiring carries only "hot" cables from the machines, and in event work is being done close to the machine, there is nothing to prevent a conventional connection if desired.

Distribution outlet connections for the cables are the same as those furnished on the generator itself, hence no special working cables are required. The ground cable uses a heavy clamp to connect to the floor pipes which form a "ground" common to all machines.

A color code is used on the distribution outlets, corresponding to a band of identical color on any individual machine. The welder makes the usual current adjustments on the generator he is using, and must take care to tap into the same color with his "hot" working cable. Red, orange, yellow, blue, black and silver are the colors used on the six machines in use at present.

There are about eight outlets conveniently located in the walls around the working area, in addition to two in an overhead position to the central area of the working space. Each can be used with all six machines except the two center outlets, which are connected to only four machines.

IDEAS—Wanted!

Plant operators, foremen, superintendents—How do you do it around your own refinery? Send in your own original contributions. Possible subjects might include operating shortcuts, time and labor-saving gadgets, repair tools, accident and fire prevention ideas. Include photographs, drawings, or graphs, if available.

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Gasket-Cutting Time Reduced About 80% With Special Tool Used on Drill Press

GASKETS can be cut quickly in sizes up to 6 in. in one operation using a drill press tool developed in the pipe shop at the Baytown refinery of Humble Oil & Refining Co. Use of the device is now general practice in the pipe shops at the refinery, and cuts down the time required to about 20% of its former value.

The previous method, using a punch or hand-knife, not only tried the patience of the workman, but usually gave him a nice crop of blisters if he cut very many. Consequently everybody dodged the unpleasant job as long as possible.

As shown in Fig. 1, the cutting tool tapers to fit in the chuck of the drill press. It can be modified for almost any type of press. Attached to the shank at right angles is a bar which carries two knives in holders which can be slid along the bar to make both inside and

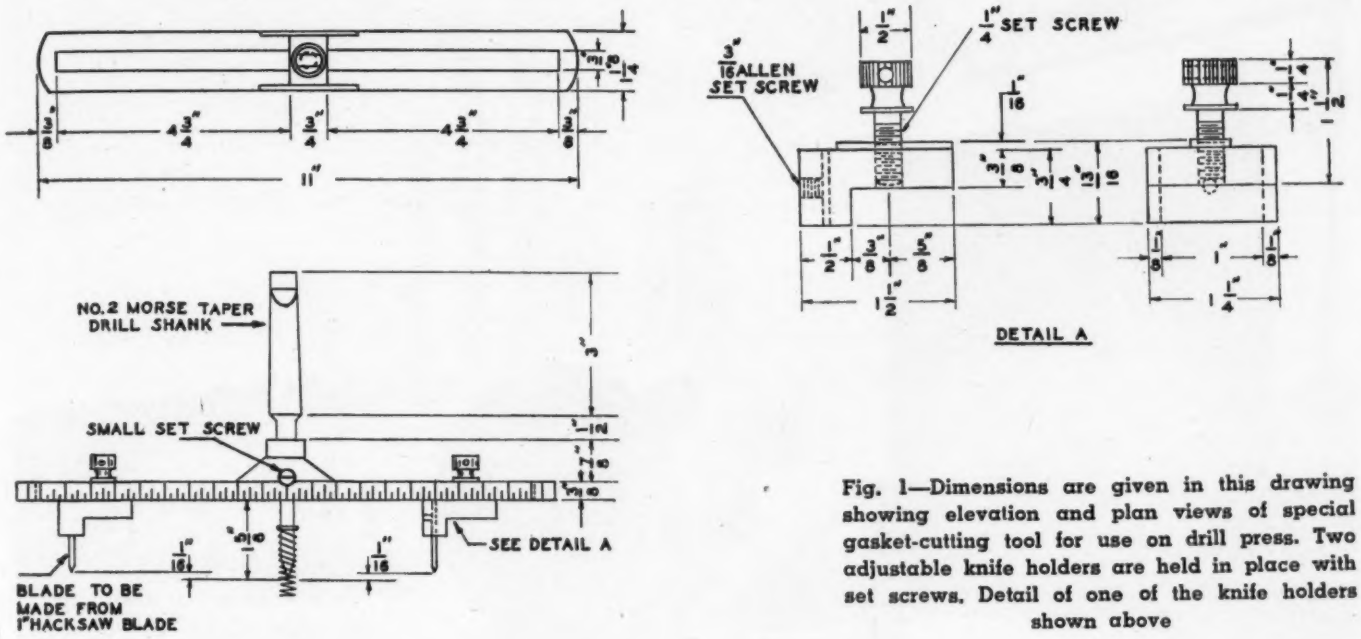

Fig. 1—Dimensions are given in this drawing showing elevation and plan views of special gasket-cutting tool for use on drill press. Two adjustable knife holders are held in place with set screws. Detail of one of the knife holders shown above

outside cuts simultaneously. A mechanic's rule or a specially-fabricated scale attached to the bar facilitates adjustment of the cutting knives to the desired dimensions. The tool shown in the illustration cost approximately $75 to build.

The earliest model of the tool was first intended for small gaskets and was operated in a hand drill, without success. Although too light for continued use in a drill press, it demonstrated that between 1500 and 2000 4-in. gaskets or smaller could be cut in one day—by hand the job would have taken a week.

An additional advantage of the device is that gaskets are accurately cut, permitting utilization of most of the gasket material. There is less spoilage than occurred with hand methods when knives or punches slipped.

Hydraulic Controls Used for Flow Rate And Liquid Level in Cooling Tower Sump

By ALFRED KRIEG, Supervisor, Instrument Department
Socony-Vacuum Oil Co., Inc., Paulsboro (N. J.) Refinery

CONTROL equipment was required to maintain the flow rate and level of a water sump on a cooling tower at the Socony-Vacuum Paulsboro refinery. However, because of the remote location of the tower, compressed air for instrument operation was not available, and it was decided to operate the controls hydraulically.

The control method, as shown in Fig. 2, utilizes the water supply itself for operation. A reducing regulator maintains a pressure of 20 psi. on the pilot line to the diaphragm motor valve and to the bleed. This diaphragm motor valve is a conventional needle type equipped with a 20 psi range differential spring, and under normal operating conditions is at maximum open position.

The ball float in the sump operates a needle valve in the pilot line regulating the amount of bleed. By increasing or decreasing the line pressure, it opens or closes the diaphragm motor valve in the water supply, thereby holding the sump level constant.

As the operation of the tower involved treated water, a flow rate control on the line was also required so as to limit the maximum demand. When process units are shut down, the equipment is generally drained, and starting up requires refilling of all exchangers and piping. If this refilling operation is attempted at a high flow rate, the normal supply to other units and processes in the plant is reduced below the safe amount.

The limiting orifice in the water line is designed to pass a maximum flow of 600 gpm. Should there be an increased demand for water and this maximum rate is exceeded, the 20 in. differential through the orifice will throttle the pilot line valve. Water is then supplied to the sump as required for normal maximum operation.

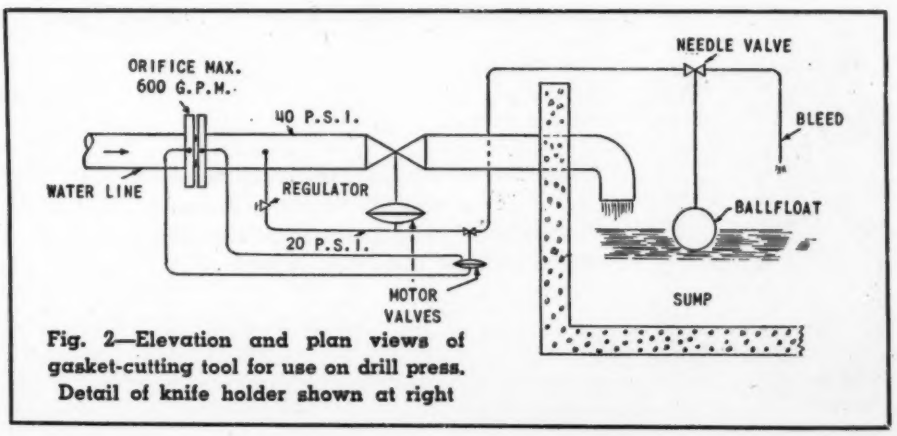

Fig. 2—Elevation and plan views of gasket-cutting tool for use on drill press. Detail of knife holder shown at right

SIMPLIFIED DESIGN FOR ACCURATE LOW-COST OPERATION

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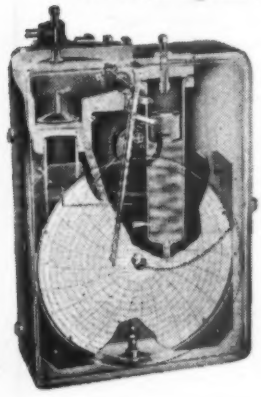

Technical literature, on Indicating, Recording or Integrating Flowmeters, Pressure Regulators, Liquid Level and Flow Controllers will be mailed on request.

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Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Developments disclosed in the patents reviewed below include:

Olefins that can be converted to acids when reacted with carbon monoxide.

The use of a suitable cation surface active emulsifier with insecticides.

Tetrathiophosphate, a metal wax stabilizing additive for lubricating oils.

Branched Acids from Iso-olefins

OLEFINS can be converted to acids when reacted with carbon monoxide in presence of a mineral acid, but it seems that a silver-lined reactor is required. In du Pont's patent 2,419,131, there are described a number of examples on the production of acids from C_4 to C_9 and higher olefins.

When 56 parts of isobutylene are introduced in a reactor containing 134 parts of 73% aqueous sulfuric acid and carbon monoxide is admitted up to a total pressure of 200 atm., agitation at 100° C. for 8 hrs. brings the pressure down to 90 atm. and, on neutralization of the acidic product, 54 parts of organic acids are obtained, 60% of which is trimethylacetic acid.

Reaction in a simple manner, using butadiene dimer (vinyl cyclohexene) as raw material, gives a sodium salt which foams strongly when shaken with water.

Insecticides

MINERAL oils, which have long been used as insecticidal sprays, are usually applied in the form of emulsion with water. For foliage spraying, they are ordinarily emulsified with 96-99% of water, and in dormant spraying, with as little as 95% of water. The water acts as a carrying agent for the oil and effects a distribution of the oil over the plant. However, the water also carries considerable quantities of the oil from the sprayed object.

One method of minimizing this loss of oil, as described in Shell Development Co.'s patent 2,418,652, involves the use of suitable cation surface active emulsifiers which are added in amounts which do not cause emulsification to an aqueous carrying medium containing the insecticidal suspensoid. When this mixture is sprayed on fruit or foliage, a smooth and uniform deposit of unusual magnitude of the insecticide is obtained.

The effect of the action surface-active compounds as depositing agents may be explained on the basis of electro-kinetic phenomena. Emulsified oil globules, as well as wet leaf surfaces, normally possess negative electrostatic charges. The mineral oils are normally emulsified by mechanical agitation or in a spray machine or by addition of oil-soluble emulsifiers such as sulfonates, fatty or naphthenic soaps, etc., most of which are anion active or neutral, so that they either further increase the negative potential on oil globules and leaf surfaces, or else have no effect on the electrostatic charge.

It is believed that the effectiveness of the cation surface-active compounds as depositing agents is due to a reduction in the negative charge or the establishment of a slight positive charge on the emulsified oil globules and a consequent reduction in the stability of the emulsion when in contact with the negatively charged leaf.

Particularly suitable for this purpose are the salts of hydrophilic acids, e.g. malic acid, and the basic condensation products of high molecular weight carboxylic acids or mixtures of different high molecular weight carboxylic acids, e.g. palmitic and stearic acids, with alkanol amines. Thus, for example, the salt of malic acid and the acid amides produced by condensing a mixture of palmitic and stearic acid with ethanol ethylene diamine is particularly effective. This salt is referred to as malate of:

$$C_{15 \text{ and } 17}\ H_{31 \text{ and } 33}\ (C = O) - NH(CH_2)_2 - NH - (CH_2)_2 - OH$$

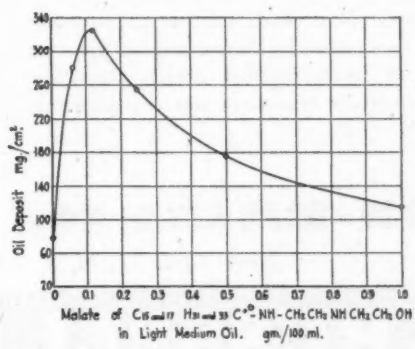

Fig. 1—Effect of cation-active additives in increasing amount of insecticidal oil sprays deposited on plants (Shell—U. S. 2,418,652)

However, the quantity of this cation-active additive must be kept below a certain maximum in order to be effective for increasing deposits of the insecticide. As can be seen from Fig. 1, if quantities above the predetermined maximum are used, the additive becomes ineffective as a depositing agent. This effect is believed to be due to such a complete reversal of the charge on the oil globules when more than certain amounts are added, that there results an emulsion of positively charged oil globules of sufficient stability to be carried off by the water despite the attraction offered by the opposite charge of the leaves.

Lubricant Additives

AMONG the newer stabilizing additives for lubricating oils is a metal wax tetrathiophosphate disclosed in Continental Oil Company's U. S. Patent 2,417,826. The compounds have formulas represented by $M_vM'_wM''_xR_y(PS_4)$ in which M, M' and M'' are any of the metals: aluminum, antimony, barium, cadmium, calcium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, nickel, sodium, tin and zinc. R is a wax olefin group, while v, w, x, y and z are small whole numbers (1-5).

These oil soluble compounds are prepared by the following sample procedure: About 18 parts by weight of calcium sulfide, 56 parts phosphorus pentasulfide and 16 parts sulfur are mixed and placed in a container tightly covered to exclude air. The mixture is fused for 1 to 1½ hrs. at 550° F. and then cooled and pulverized. The pulverized product is mixed with 209 parts of wax olefin and the mixture heated for one hour with constant stirring at 390° F. An oil soluble product showing 7.2% ash is obtained, and no uncombined sulfur is present, as evidenced by the copper strip test.

The *wax olefin* is prepared by chlorinating (at about 150° F.) oil-free paraffin wax of low melting point and containing 18-24 carbon atoms per molecule to a chlorine content of 8-12%. The monochlor fraction is separated by sweating and is dehalogenated by mixing with one-tenth

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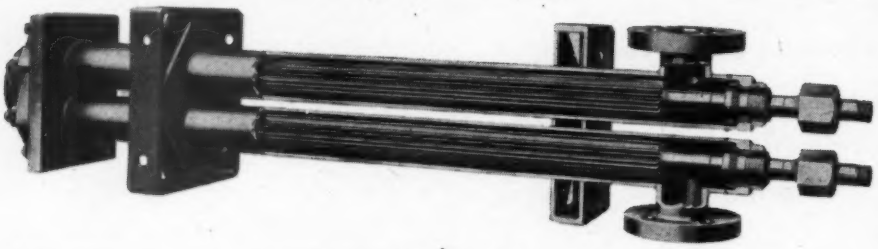

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of its weight of lime and heating for 1-5 hrs. at 200-500° F.

As to the choice of the metal to be employed, alkali or alkaline earth elements are preferred for detergency, while tin or lead are preferred where emphasis is placed on corrosion control. Copper is said to be most desirable for extremely corrosive conditions. Where detergency and oxidation control are required, zinc is preferable.

Selected Patents of the Month

U.S. Reissue 22,836 (Flame Cultivation, Inc.)—Flame cultivation.

U.S. 22,412,550 (Pure Oil)—Ethyl halides.

U.S. 2,414,812 (Houdry Process) — Contact mass for catalytic hydrogen reactions of rather broad coverage.

U.S. 2,414,816 (Standard Oil Development)—Dehydrogenating butenes to butadiene.

U.S. 2,414,817 (Standard Oil Development)—Quenching and cooling diolefins.

U.S. 2,414,852 (Standard Oil Development)—Circulating finely divided solids.

U.S. 2,414,880 (Godfrey L. Cabot, Inc.) — Cyclobutane by irradiation of cyclopentanone.

U.S. 2,414,884 and 5,003 (Phillips Petroleum) —Purifying HF.

U.S. 2,414,889 (Standard Catalytic)—Destructive hydrogenation.

U.S. 2,414,951 (Shell Dev.) — Metal sulfide catalysts in vapor phase treating of oils.

U.S. 2,414,962 (Universal Oil Products)—Butadienes by dehydrogenation.

U.S. 2,414,963 (Standard Oil — Ohio)—Desulfurization with sulfides.

U.S. 2,414,973 (Universal Oil Products) — Catalytic cracking.

U.S. 2,415,006 (Phillips Petroleum)—Butadiene separation.

U.S. 2,415,009 (Shell Dev.)—Butadiene stabilization.

U.S. 2,415,061 (Shell Dev.)—Vapor phase isomerization.

U.S. 2,415,065-6 (Shell Dev.)—Cyclohexane.

U.S. 2,415,411 (Gulf Res. & Dev.)—Vacuum distillation.

U.S. 2,415,438 & 54 & 99 (Gulf Res. & Dev.) — 1,1,3-trimethyl-cyclopentane by cyclic polymerization of isobutylene.

U.S. 2,415,441 (Houdry) — Preparing contact materials.

U.S. 2,415,444 (Ruddies)—Tetraethyl lead.

U.S. 2,415,453 (Universal Oil Products) — Bicyclo-olefinic compounds.

U.S. 2,415,530 (Pure Oil)—Isobutane production.

U.S. 2,415,628 (Anglo - Iranian) — Branched chain alkanes.

U.S. 2,415,697 (Texas Co.)—Asphalt compositions.

U.S. 2,415,699 (Standard Oil Development)—Pour depressor.

U.S. 2,415,700 (Standard Oil Development)—High quality Diesel fuel.

U.S. 2,415,717 (Standard Oil Development)—Alkylation of isoparaffins.

U.S. 2,415,800 (Shell Dev.)—Controlled oxidation of alkylated aromatic hydrocarbons.

U.S. 2,415,733 (Standard Oil—Ind.) — Unitary isomerization—alkylation system.

U.S. 2,415,833 (Standard Oil Development)—Lubricant containing thioether stabilizer.

U.S. 2,415,836-8 (Standard Oil—Ohio) — P-S E.P. lubricant.

U.S. 2,415,851-2 (Phillips Petr.)—Disulfides.

U.S. 2,415,890 (M. W. Kellogg & Co.)—Isomerizing butane.

U.S. 2,415,904 (Lion Oil Co.)—Oxidizing H_2S.

U.S. 2,416,011 (Phillips Petroleum)—Recovery of SO_2-free HCl from $AlCl_3$ sludge.

U.S. 2,416,133 (General Chemical) — Boron trifluoride.

U.S. 2,416,192 (Union Oil) — Petrolatum sulfonate.

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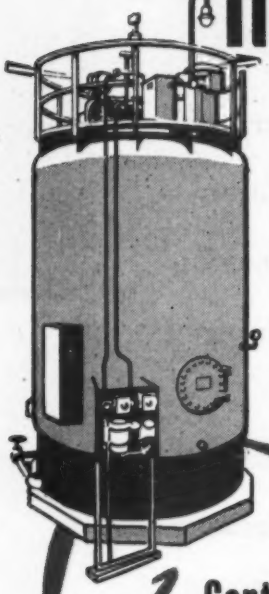

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Questions on—

Fluid Process — *Cycloversion*

T.C.C. Process — *Suspensoid*

Answered by—

D. J. BERGMAN, Universal Oil Products Co., Chicago.

J. W. BERTETTI, Root Petroleum Co., El Dorado, Ark.

HUGH A. NEAL, Phillips Petroleum Co., Bartlesville.

C. O. ANDERSON, Globe Oil and Refining Co., Lemont, Ill.

H. D. NOLL, Houdry Process Corp., New York

J. B. GODWIN, Magnolia Petroleum Co., Beaumont, Texas.

R. L. PURVIN, Consulting Engineer, Dallas.

Important operating data on catalytic cracking processes was presented, in the form of answers to questions, at a Panel Discussion conducted by the Western Petroleum Refiners Assn. as a part of its annual meeting in San Antonio, March 24-26.

Prepared questions and those submitted from the floor were answered from among a panel of seven authorities, including representatives of the process companies and of plants operating them. Chairman was R. R. Irwin, White Eagle Division, Socony-Vacuum Oil Co., Kansas City.

Below are presented selected questions and answers from the Panel as taken from the transcript of the proceedings made by WPRA.

Fluid Process

> Q.—What do you consider the most satisfactory method of controlling the operation of a Fluid catalytic cracking unit?

Dr. Bergman—Principal operating variables and indicators are; fresh feed rate; temperature of the charge; flow of catalyst, or catalyst-oil ratio; reactor temperature; reactor level; recycle rate; air rate; regenerator level; regenerator temperature; carbon on the regenerated catalyst; carbon dioxide in regenerator gas; catalyst makeup rate.

Many of these variables are not independent but do resolve themselves as a result of picking your primary variables. The plant inherently has a lot of stability due to storage of quite a lot of catalyst and heat, so changes occur smoothly and slowly.

In the case of simple heat balance plants, using heat exchange only for feed preheat, we have found that flow control of the feed and air, flow control of catalyst to the reactor, which maintains essentially a constant temperature in the reactor, level control of catalyst to the regenerator which maintains with constant feed a fixed space velocity, and a differential pressure control between the reactor and the regenerator which controls the gas outlet from the regenerator, gives a very smooth set of controls.

Dr. Bertetti has one additional item of flexibility in his unit, a heating furnace, which he is using in addition as a means of assisting in operating control.

Dr. Bertetti—I think our method of control is a slight departure from that used by some others. We have the reactor level controlled by the regenerated catalyst slide valve. The spent catalyst is on hand control, so that essentially we have the catalyst-oil ratio fixed and we have the furnace as one control variable and, thereby, control the temperature in the reactor. We have found it quite satisfactory since operation is very smooth. The point of our primary variable in controlling the unit is the level in the reactor. That then is varied up or down depending on coke rate as shown by oxygen in the flue gas or carbon on the regenerated catalyst.

> Q.—Is it considered practical to convert an older type of unit to one suitable for microspherical catalyst? What economic advantages might be expected besides elimination of the Cottrell precipitator?

Dr. Bergman—We consider it entirely practical to run MS in older type units. Sometimes no change may be required but in other cases changing the catalyst lines might be desirable both from the standpoint of maintenance on the old internally-insulated lines and of increasing velocity in those lines to carry MS catalyst. The principal advantage of use of MS would be elimination of secondary recovery equipment because of reduced rate of attrition. The secondary advantage is that MS catalyst with its round form seems to give less erosion. Accelerated laboratory tests show silica alumina MS has about one-fourth the attrition, the breaking up into fines, of ground silica alumina of the same size, and about one-sixth or one-seventh that of natural catalyst. Laboratory erosion tests show that MS erodes at about one-seventh the rate of ground synthetic alumina catalyst of the same size.

> Q.—On a given feed stock and at a given activity level, what are relative make-up rates for natural and synthetic catalysts?

Dr. Bergman—The answer depends almost altogether on the specific case, because of the different behavior of synthetic and natural catalysts to specific charge stocks and the sulfur content or other poisons in those stocks. If we selected a case where the regenerator temperature was normal or slightly low, in the neighborhood of 1050° F. and a low sulfur stock, there probably would not be much difference in the rate of drop of activity of natural and synthetic catalysts. The natural, of course, starts out at a little lower activity than synthetic.

In a case with a high sulfur stock and high regenerator temperature, say 1100° F. or thereabouts, there would be marked depreciation of the natural catalyst as compared with the synthetic. A good deal of that difference may be made up by hydration of the catalyst, which has been recommended by the Filtrol people.

If the feed stock were low in sulfur and the regenerator temperature high, again there would be a faster drop in activity by the natural catalyst which has

a somewhat lower temperature stability than synthetic.

In any case, the decline rates depend so much on a large number of factors—amount of steam, temperatures used, sulfur, and other factors—that it isn't possible to correlate from one stock to another on activity and feed rates.

Q. — Does high sulfur in charge, say, up to 1.7 wt.-%, affect octane numbers, catalyst activity, or coke formation?

Dr. Bergman—High sulfur stocks have been run in a number of units, and in addition they have been explored in pilot plants. High sulfur does not seem to affect octane number particularly and the cracking of gas-oil with, say 2.1% sulfur, resulted in a gasoline with less than .15% sulfur.

High sulfur stocks do affect catalyst activity markedly, particularly natural catalyst. In one case in the laboratory a natural catalyst which had been aged for some time on Mid-Continent gas-oil was used to run a 2.1% sulfur West Texas stock. The activity declined from 30 UOP weight activity to 16 in two days.

Synthetic catalysts are rather more stable and the activity remains higher under high sulfur conditions.

Dr. Bertetti is running fairly high sulfur stock at his plant and I should like him to give some information on the octane number.

Dr. Bertetti—We are now running a comparatively heavy gas-oil, with approximately 1.6 or 1.7% sulfur, and we obviously wonder how much it is costing us in capacity, activity and octane numbers; but insofar as our own data are concerned, we have seen little change in octane numbers when running with 0.722% as against coming up to 1.7 wt. %. We have found that on our C_5 to 400 gasoline, the Motor clear runs from about 78 to 80, and with 3cc of lead from 84 to 87. On Research the clear octane is from 90 to 91, and with 3 cc of lead 95 to 97. That shows 10 to 12 octane numbers between Motor and Research.

Of even greater interest to us is the blending value in our plant gasoline. The catalytic cracked gasoline is blended with plant gasoline consisting 50-50 of straight run and thermally run. The Motor blending octane number is 87, the Research blending octane number is 103, or a spread in blending value of about 16.

We have noted a considerable effect on catalyst activity when running the higher sulfur stock, at least we are now attributing our activity decline to the high sulfur. Within the past three months, since running the high sulfur stock, the activity has declined from about a 45 UOP volume activity to 30, or a corresponding weight activity of 26 down to 17. We have increased our makeup rate and are attempting to rehydrate the catalyst as suggested by Filtrol. That has been only during the past week or two so we have no definite data. There apparently has been improvement.

Q.—In a unit of limited coke burning capacity, can more gasoline be produced by feeding the heavy or light gas oil fractions from a given crude?

Dr. Bergman—For the refiner who has somewhat more charging stock available than he has plant to run it, the question comes up as to whether he should run the light or heavy stock, and which will produce the most gasoline.

Laboratory correlations over quite a wide range show that the weight percent of coke and of gasoline on charge stock remained nearly equal for the same conversion over a fairly wide range of gravity of stock, as long as you don't start cutting into the asphalt on the end point of your gas-oil. This says that the volume per cent of the gasoline on a heavy charge is somewhat greater. That is purely on the basis of per barrel of charging stock but, if the weight per cent of coke is constant, then you can make the same number of pounds of gasoline with the light or heavy stock directly off the unit.

When you take into account the gasoline made on the unit, plus poly, there is a very slight decrease in yield, probably less than 1%, over the normal range from 32 down to 26 gravity charging stock, due to the fact that, with the heavy charging stock, you charge a few less barrels to charge the same number of pounds of stock. The indication is that you will make just about the same amount of gasoline with the heavy stock as with a light stock if you are limited in coke on your plant.

Q.—What types of catalyst strippers are now considered most efficient for adaptation to old units and for new units? And — What are the relative advantages of the following media for injection and stripping; steam, flue gas, methane?

Dr. Bergman—The basic principle of good stripping in a Fluid unit is to have countercurrent flow of catalyst and steam to remove the hydrocarbon from the down-flowing catalyst. As soon as you put in sufficient steam to do that you fluidize your bed; accordingly, in order to get countercurrent action, it looks to be a desirable thing to use several zones, which can be separated by the use of horizontal, perforated baffles. It is also better to use a single stripper rather than multiple to prevent poor action between different small units.

The different materials used for stripping have been steam, flue gas and plant gas or methane. Steam has been objected to because it has a deactivitating effect on the catalyst. However, the cost of generating steam is comparatively low in most cases. Of course, down here in Texas gas is cheap. The undesirable effect of flue gas is what it does to condensers.

You can put steam into hydrocarbon vapors, and the increased heat to be removed can be taken out with the same surface in a condenser, because the heat transfer rate increases with steam present. On the other hand, flue gas blankets the surface and decreases the rate, so you must add more surface on the condensers. You also have to increase the size of the towers in the gas concentration system up to the point where you vent this gas. Roughly, the same thing applies to the use of methane for stripping because it likewise would blanket the surface.

Q.—What variables affect carbon monoxide formation and what can be done to promote burning to carbon monoxide rather than to carbon dioxide?

Dr. Bergman—Laboratory investigations of the factors influencing CO_2-CO ratio involve temperature, particle size and catalyst composition. There is not much effect of the particle size in the range of ground or MS catalyst. There is an effect of temperature. You do get a minimum value of a CO_2-CO ratio, that is, the largest amount of CO, by running in the neighborhood of 1200° F. This is too high for regeneration temperature, and in the range of ordinary operation, about 1100° F. on synthetic and 1050° F. on natural, you find somewhere between 0.8 and 1 CO_2-CO ratio on synthetic and about 1.5 to 1.7 on natural catalyst.

Dr. Bertetti—I should like to comment on the significance of the ratio. In a unit of fixed air capacity for regeneration, whatever may be limiting that air rate, reducing the CO_2-CO ratio from about 1.9 to 1.0, other factors remaining constant, would result in an increase in coke capacity of about 6%.

There is still another effect in reducing over the same range. The heat released in the regenerator will decrease about 10%.

In speaking of increasing coke burning capacity, the per cent of oxygen and flue gas is quite significant. There is an increase of coke burning capacity of about 5% for each 1% decrease in percent oxygen in flue gas.

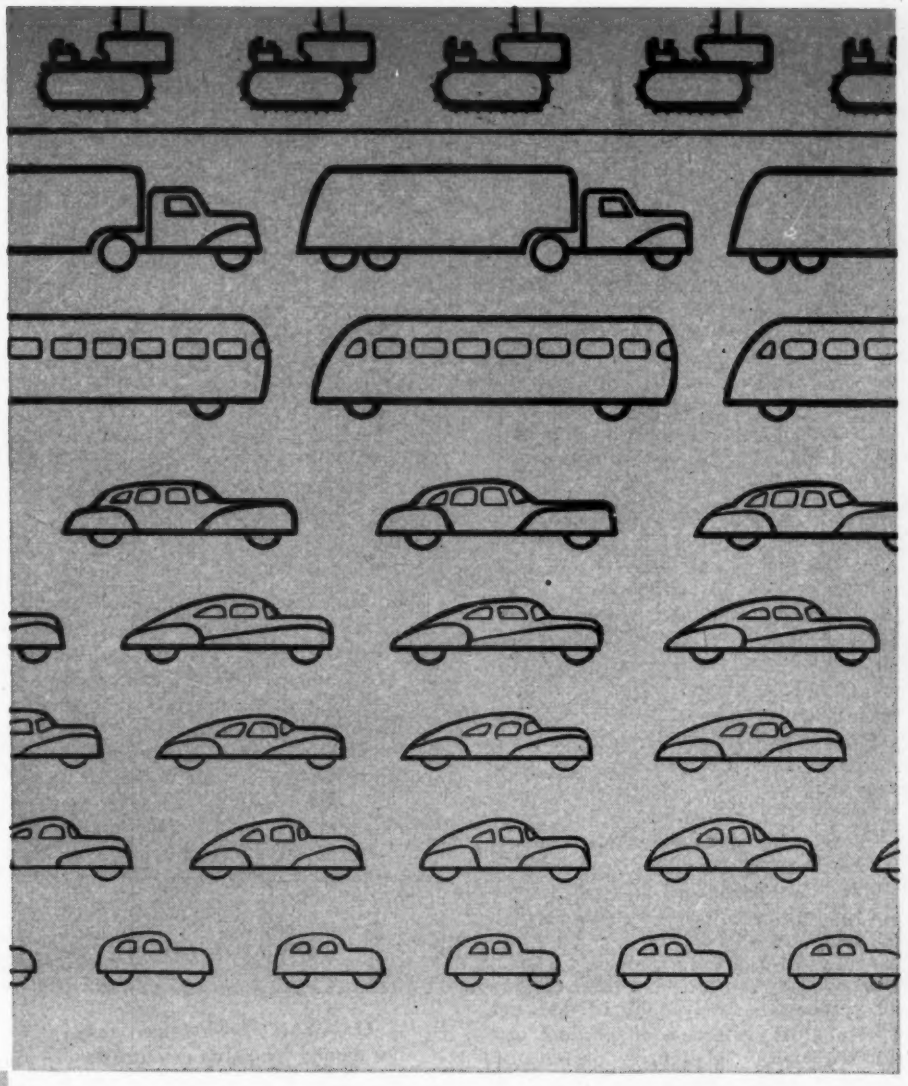
Q. — What are considered maximum practical regenerator bed temperatures for natural and for synthetic catalysts?

Q.—Is catalyst activity affected by residence time in the

high

medium

low



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regenerator; that is, if efficient burning could be accomplished with a smaller regenerator inventory, would activity decline be at a lower rate?

Dr. Bergman—On the first question, experience indicates that for natural catalysts 1050° F. is ordinarily a nice comfortable temperature to work in the regenerator. That, of course, is against this maximum CO_2-CO ratio, but is dictated by deactivation effect of temperature and steam and the necessity for keeping reasonable makeup rates. On synthetic catalyst, which is somewhat more stable, 1100° F. seems to be a satisfactory temperature.

On the second question, one of the factors adversely affecting catalytic activity is prolonged exposure to high temperature in the presence of steam. Therefore, maintaining a larger regenerator inventory than is necessary for satisfactory coke burning must result in increased loss of activity of the inventory and increased makeup rate for a given activity level. In other words, the regenerator is not the place to store your extra catalyst.

Q.—At a given conversion percentage, how are gasoline and coke production affected by catalyst activity and reactor temperature?

Dr. Bergman—At a given conversion percentage, catalyst activity does not make a great difference in product distribution with laboratory deactivated catalyst. With catalyst deactivated in the plant it depends on the specific method of deactivation. Sulfur deactivation has been mentioned earlier as being harmful and increasing coke. Temperature deactivation likewise tends to increase coke.

With regard to reactor temperatures there is rather a different story. For example, at a fixed 50% conversion level and taking reactor temperatures of 850 and 950°F. on a 28 gravity Mid-Continent gas-oil stock, the immediate effect of the higher reactor temperature is to reduce the volume per cent of gasoline and the weight per cent of coke. The volume percent of gasoline might be reduced from 43.1 down to 41.0 for a 10-lb. gasoline. The coke reduces under the same conditions from 3.9 to 2.9 wt.%. This is using a synthetic catalyst.

At the same time the effect of the increased temperature is to produce more gas at higher olefin content, so that the over-all gasoline production resulting from running at a higher reactor temperature comes out nearly the same, 47% in the case of the 850°F. and 48.3% for the 950°F. temperature. That includes the poly make, but the poly gasoline is nearly double, so you need a larger poly plant to balance your operation.

Perco Cycloversion

Q.—What advantages can a refinery expect by using the Perco Cycloversion process?

Mr. Neal—The term Cycloversion is used to cover the catalytic process of the Phillips Petroleum Co. and includes catalytic desulfurization, catalytic reforming and the gas-oil catalytic cracking. Our statements will be limited to desulfurization and reforming, for the reason that all refiners have some gasoline they must upgrade by removal of sulfur. Mr. Anderson, who is here with us can tell you some of the benefits to his company from desulfurization of a high sulfur West Texas straight-run gasoline.

Mr. Anderson—At present we have a desulfurization unit of approximately 5000 b/d capacity. We are desulfurizing 420 endpoint West Texas gasoline. With straight desulfurization we get an octane improvement of about 7 to 10 octane leaded on the entire cut. This desulfurized stream is fractionated into a light cut and a thermal reformer charge and the low 350 endpoint material goes into finished gasoline. This per cent of 350 endpoint gasoline with the 7 to 10 octane improvement upgrades our total plant gasoline about 2.4 octanes. This is for both ASTM and Research octane numbers.

Q.—What advantages may be gained by Perco desulfurization prior to the thermal reforming?

Mr. Neal—A number of refiners who already have thermal reforming have asked us that question and we have some specific data on it. On some of the tests we ran on a West Texas high sulfur straight-run gasoline, with desulfurization prior to thermal reforming the general results are these: For the same octane value on reformed materials in both cases, the desulfurization prior to thermal reforming gave an increase of about 4 vol. %. With the same percentages of gasoline, the desulfurization added about 3 or 4 octane numbers to the final gasoline.

Q.—What advantages are obtained by Perco desulfurizing of a low sulfur gasoline?

Mr. Neal—We have some plants in the Michigan area where the sulfur is moderately low. The advantages gained are in the neighborhood of 4 or 5 octane numbers merely by desulfurizing even though the sulfur is moderately low.

Mr. Anderson—We desulfurized a low endpoint, straight-run gasoline, similar to the sulfur content I mentioned a few minutes ago. On the low sulfur content, charging 0.026 in sulfur, the sulfur in our product was 0.003. It was 80.3 leaded octane ASTM. After desulfurization we added about 2.5 octanes to get 82.5 to 82.7 ASTM octane.

Q.—Will Perco catalytic reforming upgrade cycling plant gasoline?

Mr. Neal—We have made some extensive studies on catalytic reforming of cycling plant distillates. The investigation was carried out mainly for the purpose of giving a spread between ASTM and Research octane rating. We have proved that the catalytic reforming of the cycling plant ditillates will give a very nice spread. The amount of spread you want is what dictates the operating conditions, of course, and will also determine the amount that is converted to fuel gas.

Q.—Describe briefly the method of catalyst regeneration and control.

Mr. Neal—Catalyst regeneration in the Perco Cycloversion processes is carried out with steam and air mixture. The carbon laid down, of course, determines the amount of air and we control the ,regeneration) temperature by the quantity of steam.

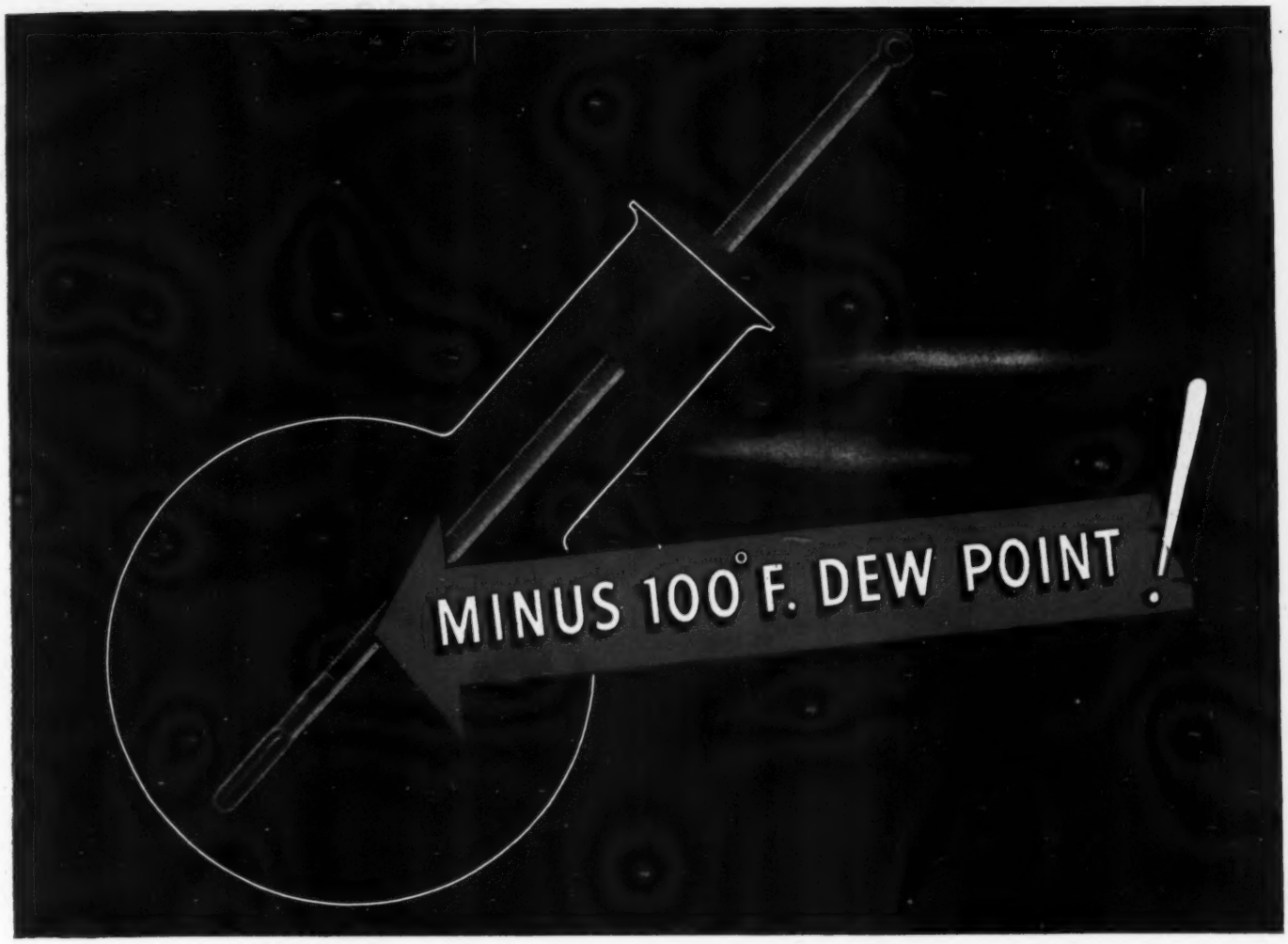
Mr. Anderson will describe the determination of the frequency that they use at Globe.

Mr. Anderson—With our regeneration we determine frequency of regeneration by the dropping off of octane increase of the desulfurized product. We are able to process between 4000 and 5000 bbls. per ton of catalyst. This is on the desulfurization with low carbon laid down. The regeneration is a very simple matter. We first purge our reactor, using steam superheated to approximately 800 or 850°F.

Then air is introduced in the amount of about 3.5 volumes per pound of steam. The temperature in our reactor is held at a maximum of 1275°F. This temperature is controlled by increasing or decreasing the amount of steam. Regeneration is continued until the temperature in the outlet of the reactor falls below 900°F. which, on tests run with analyses on flue gases, indicates that the oxygen is breaking through rather rapidly and that burning is complete.

Q.—Give some of the operating costs of Perco desulfurization and reforming under certain conditions?

Mr. Neal—Over a number of desulfurization plants we have operating, the average cost for desulfurization is 6½c to 7c per bbl. The operating costs for catalytic reforming will run from 10c to 15c, depending on the depth of conversion. These figures are based on av-



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T.C.C. Process

Q.—What equilibrium catalyst activity should be held on a unit to give the most economical operation and what catalyst makeup is required to maintain this activity?

Mr. Godwin—We have set up 31 to 32 CAT-A activity on the clay catalyst and this requires 2.6 to 3.75 tons per day per unit make up of fresh catalyst. The fresh catalyst has an activity around 38 to 40. The curve has been plotted on the catalyst makeup per unit versus the equivalent catalytic activity on the basis of 10,000 to 13,000 b/d reactor charge with 100-ton circulation. Two tons per day will give 30 activity; 2.6 tons, 31; 3.8 tons, 32; 5.6 tons, 33 activity.

Q.—What length of run is readily obtainable on T.C.C. units and what stream time efficiency is obtainable?

Mr. Godwin—Magnolia has had one run of 197 days. That is approximately 6½ months. We have been on our present run 140 days. The unit is still running and we see no reason why it should not run from one to three months longer. The Tide Water Associated Oil Co., at Bayonne, N. J., made their initial run of 240 days, and we have other refiners reporting runs of 217 days and 146 days. I understand that the Lubrite plant in East St. Louis has been on a run now since Oct. 10, 1946, approximately 6½ months, and they are planning on running until some time in April.

The stream time efficiency obtainable on our unit at Magnolia has been 91.4% for about three years and five months, and this was the first commercial T.C.C. unit to be built. We have done quite a bit of experimental work which would cut down the stream time efficiency. The Tidewater (unit) has been in operation since May, 1945, and has an average stream time efficiency of 95.1.

Mr. Noll—I don't think it is always the length of the run you make, whether you make a 400-day run or a 200-day run, but it is the over-all stream time efficiency which counts. Say you make a six-month run and are down only 10 days. That is a lot better than making a year's run and being down, say 30 days for cleanup.

Q.—What maximum throughput can be expected on a 11 ft. 5 in. reactor with concurrent flow?

Mr. Noll—We have run as high as 13,000 b/d on a 11 ft. 5 in. reactor without any serious effects, and the conversion has been in the order of 50% without any apparent difficulties. The reactors were designed originally for 10,000 bbls.

Q.—Under what pressure is steam usually generated in T.C.C. kilns and can the steam be generated at a pressure which will feed into the refinery steam system without complicating the kiln design?

Mr. Noll.—There is very little change in regenerator design, whether we design for a steam system of 250 lbs. pressure or up to 650 lbs. Most of the units were designed for around 400 lbs., because the steam is used in high temperature reboilers. We are now building a plant that is going to have a 650 lbs. system. We also have plants in operation with steam systems down as low as 250 lbs. but there is no reason we cannot go even lower or higher than these pressures.

Q.—What is the useful life of the catalyst elevator chains?

Mr. Noll—We have several runs on chains that have been in service better than three years, and I think Mr. Godwin has some actual data on Magnolia, which is the oldest T.C.C. unit in the country.

Mr. Godwin—The chain life experience has been on the average approximately 24,000 hours. At present we have one chain on the reactor kiln elevator which has been in service three years and five months, and we hope to get four months more service out of the chain.

Q.—What severity should be held to give maximum octane spread and what factors in T.C.C. cracking promote formation of the highest octane gasoline?

Mr. Noll—The maximum spread between Motor and Research octane is a function of the average reaction temperature. With clay catalysts we have found there is very little increase in spread, especially on a leaded level when you exceed 925° F. as the average reactor temperature. In addition the maximum barrels of high quality fuel occur in this temperature range.

Another factor, of course, which influences the quality of the fuel you are going to make is the type of charging stock. Obviously, naphthenic charging stocks will give higher octane levels than paraffinics at the same conversion level.

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higher Motor octane for the same conversion level, and about 2 octanes on a Research basis. This optimum temperature of 900° F. with clay catalysts is somewhat reduced when a synthetic catalyst is used. Our observations have been that around 875° F. you get the maximum barrels of high quality gasoline with the synthetic catalyst.

Q.—What are the relative merits of concurrent and countercurrent flow reactors and what factors determine the possible run lengths of T.C.C. units?

Mr. Noll—The reactors that were originally built during the war days were all countercurrent flow. Practically all our units now operate on a basis of concurrent flow. With concurrent flow far greater utilization can be made of heat capacity of oil and catalyst. With the same oil inlet and the same catalyst we will have about 55 to 60° higher average reactor temperature with concurrent than with countercurrent flow.

The factors that influence the possible lengths of runs on T.C.C. units are usually outside the catalytic section proper. Mr. Godwin gave you the data from Magnolia as well as the Tide Water operation. In that original Tide Water run of 240 days the reactor was by-passed only 17 hours, and of the total the actual part within the catalyst proper was two hours.

Q.—Does T.C.C. gasoline require any special treatment for removal of sulfur compounds or for the removal of gum-forming materials? Can a marketable No. 2 fuel oil be made on a T.C.C. unit?

Mr. Godwin—Catalytic cracked gasoline from a sweet and sour charge stock is caustic scrubbed only to remove traces of H_2S. No further treatment is necessary to remove sulfur compounds or gum-forming materials. The stability of the finished gasoline is excellent, as is evidenced by the induction period which is usually in excess of 10 hours without inhibitor. Some refiners add a small amount of inhibitor, say 5 to 10 lbs. per 1000 bbls. when long storage periods are anticipated.

Mr. Noll—I think the best evidence that it is a practical operation to cut catalytic fuels into No. 2 fuel oil is that we don't hear any complaints from customers who are doing it.

Q.—What is the maximum over-all octane from processing a Midcontinent crude by means of catalytic cracking with and without thermal reforming? What are the Motor and Research octanes, clear and with 3 cc of lead?

Mr. Noll—This question is kind of difficult to answer and, of course, many factors are involved. How much distillate do you want to make? What is the split between premium and regular? We did set up a few cases just to take a look at what a refiner would accomplish by installing catalytic cracking capacity in a refinery where he only had thermal before. Eliminating, say, 10% of the kerosene and running on a Mid-Continent crude with thermal operation, and that is all-out reforming, we will have about 68 motor-clear octane over-all gasoline, and it will go to about 80 with 3 cc's of lead. The corresponding Research would be about 73 clear and about 84 with 3 cc's of lead.

We took this same refinery and put in a catalytic unit, in which we processed the cut after eliminating straight-run gasoline and 10% of kerosene, while running the vacuum still down to asphalt. We processed that cut between kerosene and asphalt with about 1:1 recycle and made a gasoline that had about 73 Motor octane number, or a lift of about 5 over the thermal case. The leaded would be about 84 and the corresponding Research octane 78.5 clear and 89 with 3 cc's of lead.

We still have slack. We can put in a thermal reforming unit or use the existing one. If we took that same operation with exception, say, of reforming 250 to 400 straight-run gasoline we would lift the octane up another 3 to 4 points. We would have about 76 Motor clear and 86 with 3 cc's of lead, and the Research would be 83.5 clear and 92.5 with 3 cc's of lead.

Q.—Can thermal operators take over T.C.C. operation without considerable training?

Mr. Godwin—Thermal operators can take over T.C.C. operation with little training, since the complexities of T.C.C. units are far less than high pressure thermal units. The main difference in the training requires that the fundamental concept of the kiln operation be made known to the operators. We usually do that in advace of starting up any new unit. We try to explain to the operators the function of the kiln and reactor.

Q.—What is the minimum capacity T.C.C. unit which is economically feasible to construct? Are small T.C.C. units available as off-the-shelf jobs or must each one be specifically designed.

Mr. Noll—That first question is just like saying, "How much money have you and how much do you want to spend?" We can build units of any size and if the gasoline markets are going to keep up it would be feasible to construct a unit of as little as 1500 b/d capacity. We do not believe that anybody who has more than 3000 bbls. of charge stock should be without a catalytic cracking unit, because it is going to be an attractive payout with current prices. In some localities in this country where gasoline is high in price and crude relatively cheap, such as in the Wyoming and Montana areas, these small catalytic units are going to be very attractive.

These small catalytic cracking units are available off-the-shelf in sizes from 1500 to 5000 bbls. and it does not matter who builds them. There are very few changes to be made in design on these small units, so that the engineering is no problem at all.

Suspensoid Cracking

Q.—What recent improvements are there in eliminating the dangers of erosion in connection with the Suspensoid operation?

Dr. Purvin — In answering that question I think it is important to take a look at the erosion problem itself. When the Imperial Oil Co., Ltd., went into the Suspensoid operation, they began on what they call "regular Suspensoid," which means operating at about 450-lb. coil outlet pressure and 1050° F. temperature. They had very little erosion troubles under those conditions. During the war they went to what they called a "Super-Suspensoid" operation, which was designed to crack a little harder and they went up to 1090° F. on the coil outlet and approximately 250 lbs. pressure. The result was much greater erosion and the result, therefore, was that they had to do something about it. Of course, they were squeezing Suspensoid into a thermal cracking coil. They felt that, if they were designing a coil specifically for Super-Suspensoid, they could reduce the velocities below that critical point where they get erosion.

At the present time they believe that they have solved the erosion problem with Super-Suspensoid in the present coil by the use of streamlined headers. I believe the Kay Co. makes a header with a streamlined plug in it. They have also devised with the Kay people a little stainless steel collar that fits in between the header and the tube. It is about 3 in. long and it protects the end of the tube from erosion. With that they have no trouble, but you will note that with Suspensoid, which is the process that they consider is desirable for motor gasoline products, the erosion was not a problem in just regular headers and tubes.

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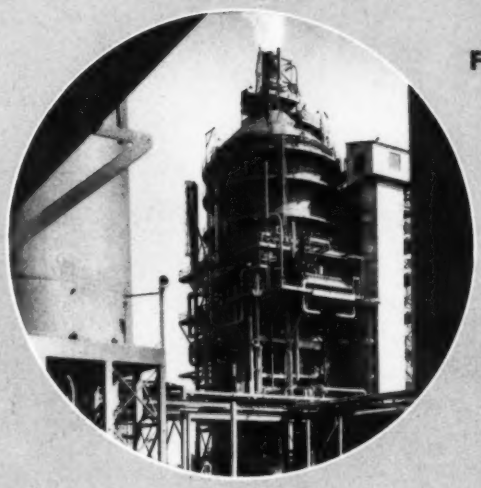

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Atmospheric Cooling Tower Size Is Based On Water Concentration for Height

By JAMES G. DeFLON
Chief Cooling Tower Development Engineer, The Fluor Corp., Ltd.

The efficient performance and most economical size of atmospheric-type cooling equipment requires careful consideration of several factors, including the velocity of the prevailing winds, the height of the tower, and the wet bulb temperature.

Five examples are presented for calculating tower size and capacity under various atmospheric conditions. The use of the given correction factor charts for each variable is explained. Results are only approximate and are given solely for the purpose of illustration.

This article is the second of two on the evaluation of cooling tower performance. The first, which appeared in the April *PETROLEUM PROCESSING*, was limited to induced or mechanical draft-type towers.

IN ATMOSPHERIC type cooling towers, water is pumped to the top of the tower, where it is discharged through a distributing system. As the water begins its downward flow, it is broken up and redistributed by the docks that comprise the filling of the tower. This continually creates newly exposed cooling surface for the air (passing horizontally through the tower) to encounter. The redistribution insures even concentration of water throughout the tower during its entire fall. A typical tower is shown in cross-section in Fig. 1.

Although initial cost for an atmospheric cooling tower (designed for a 3-mile wind) is about the same as that for a mechanical draft tower, there are certain important limitations governing its performance. It must be located broadside to the prevailing wind in an exposed area. Any surrounding structures, hills or other barriers would tend to block off the wind.

Originally, the main objection to atmospheric towers was the excessive spray loss occurring during periods of high winds. This high loss was caused by the lack of a method of separating the entrained water from the air in the conventional louver-type tower. Most manufacturers now have solved this problem by incorporating drift eliminators into the louvers.

Estimating Tower Size Performance

The method of determining the size and performance of an atmospheric type tower is shown on the accompanying charts. The purpose of these charts is to show the method of estimating the

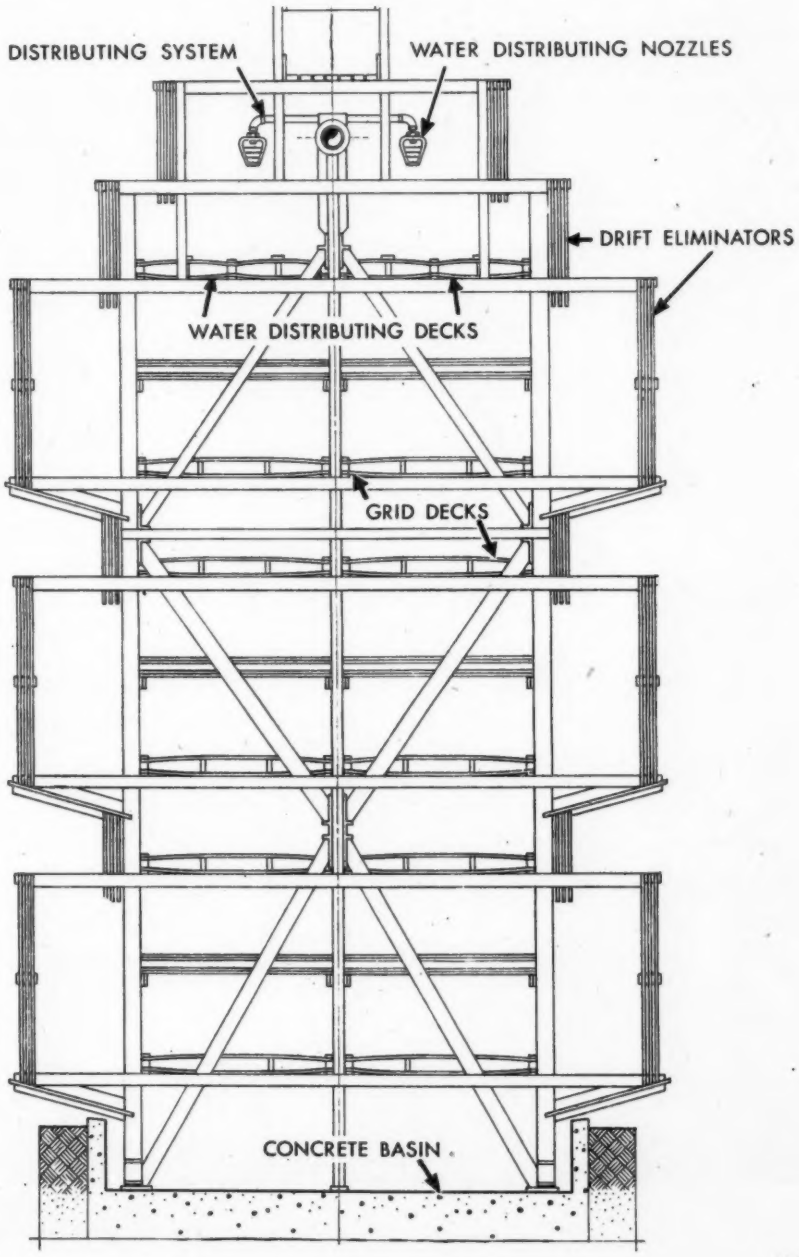

Fig. 1—Cross-sectional view of an atmospheric-type cooling tower. The function of the drift eliminators on the sides is to separate entrained water from the discharging air stream

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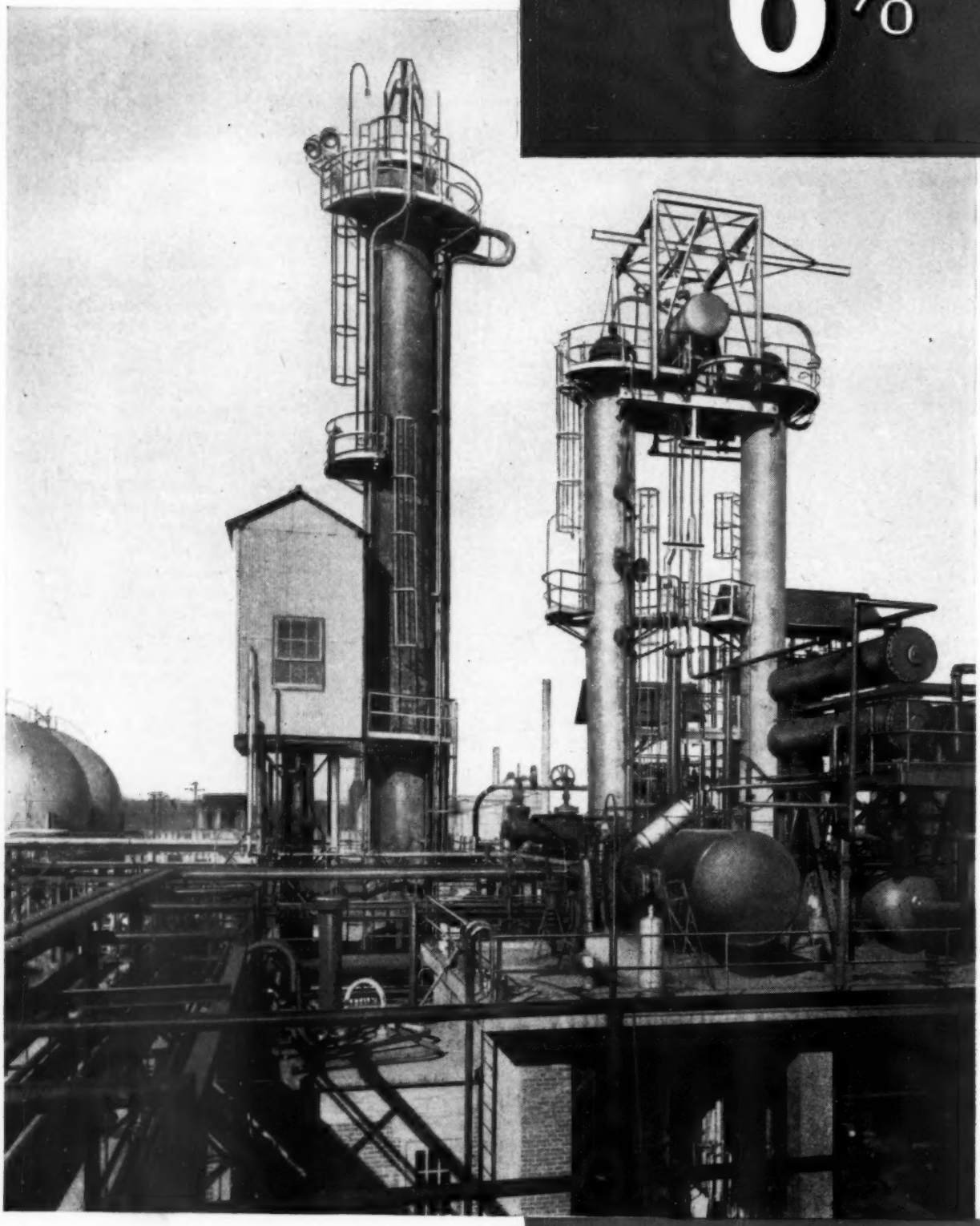

. . . and at low cost conversion

Converting a government leased catalytic butane isomerization unit to a polymerization unit paid off in a hurry for Cooperative Refinery Association, Coffeyville, Kansas.

HERE IS A QUICK PICTURE OF THIS PROFITABLE CHANGEOVER:

UOP engineers analyzed the problem. Found that simple, low cost changes would convert the isomerization unit to the new service. Engineers for Cooperative Refinery Association laid the plans for the conversion making it possible to complete the job in less than thirty days. The unit is now producing 82.5 octane number polymer with a 95 octane blending value. Overall gain, 6% increase in cracked gasoline yield from a minimum investment which paid out after only a few months operation.

This type of service is just one of the many ways UOP engineers are serving the petroleum industry. UOP processes and UOP engineering service are enabling many independent refiners to meet today's production and marketing requirements, fully utilize their equipment and keep operations at a profitable level. We shall be glad to discuss your refining problems with you.

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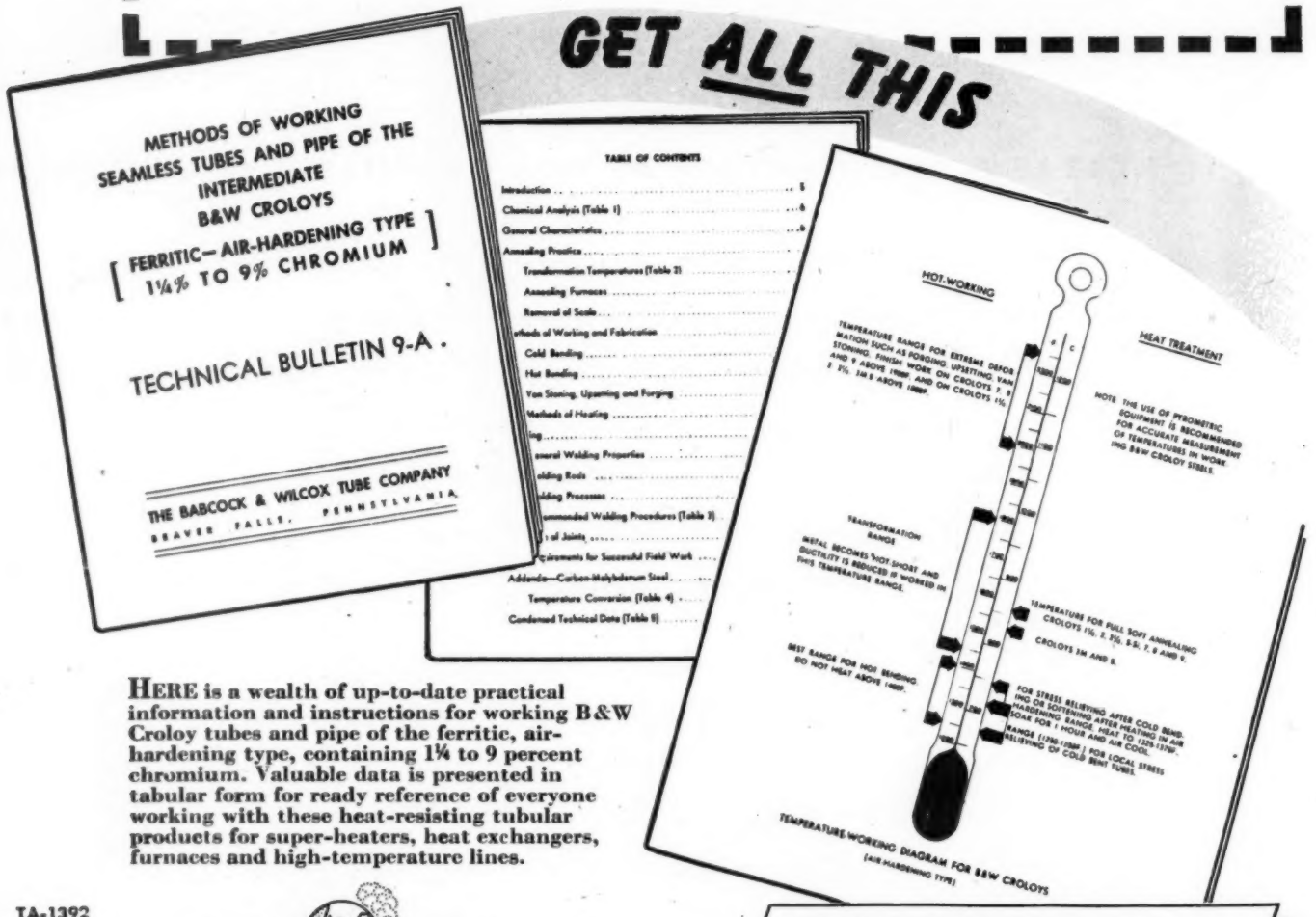
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approximate size of an atmospheric type cooling tower to meet a given demand.

The cooling capacity of any tower, with a given wet bulb temperature and wind velocity, varies with the water concentration. Thus, the problem of calculating tower size becomes nothing more than obtaining the correct water concentration for one of chosen height, which will operate under a certain wind velocity and wet bulb temperature. Once this water concentration factor is obtained, the area of a given height tower can easily be calculated by dividing the gallons circulated per minute by the concentration factor.

Five Conditions Determine Cooling

The concentration required to produce desired cooling depends primarily on the following conditions.

1. Temperature Range (T_1—T_2)
2. Approach to Wet Bulb Temperature (T_2—Twb)
3. Tower Height
4. Wind Velocity
5. Wet Bulb Temperature (Twb)

It is easily seen that because of the infinite number of possible combinations of those values, it is impractical if not impossible to have one curve from which to obtain the correct concentration factor. Fig. 2 gives the required concentration for cooling water through a certain range and with a certain approach to the wet bulb temperature, *but* this curve assumes a wet bulb temperature of 70° F., tower height of 35 ft and wind velocity of 3 mph.

Let us assume that the conditions given are unity. Then should any of these three values change, the concentration would have to be corrected for the new conditions by using one or more of the correction factors shown on Figs. 3, 4, and 5.

How Water Concentration Is Affected

Let us see how a variance of any of the three aforementioned conditions would affect the concentration of water.

Wind Velocity. The higher the wind velocity the greater the amount of air that goes through the tower. This results in greater cooling. Therefore, when the wind velocity is higher, the concentration can be greater and still obtain equal cooling.

In deciding upon a design wind condition, it is well to bear in mind that there is a period occurring during the day and night in which the prevailing wind shifts. When this occurs, there is a short period when there is little or no air movement. During such period, the tower water temperatures will rise from 2 to 5 degrees, depending on the duration of the calm and the design wind velocity. This should be evaluated in determining a design wind velocity. However, one should be aware of the fact that many atmospheric towers are designed to successfully operate at a zero wind condition.

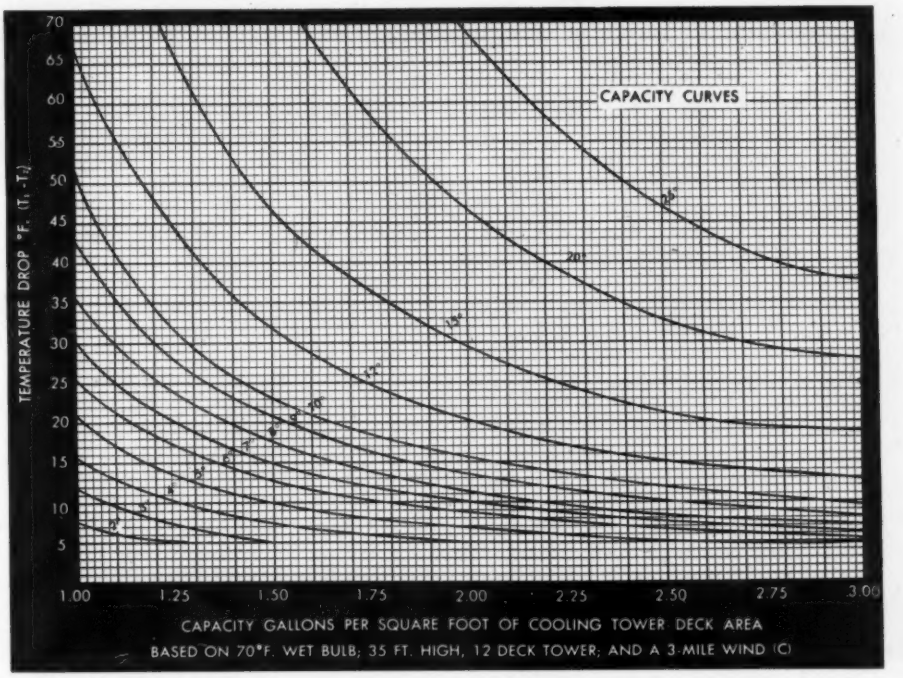


Fig. 2—Capacity curves for atmospheric-type cooling towers

Tower Height. In general it is found in atmospheric as well as mechanical draft towers that the greater the cooling range and the closer the approach to the wet bulb temperature, the higher will be the tower required to give sufficient time of contact between water and air to accomplish the desired cooling.

In atmospheric towers, the performance is limited by both maximum and minimum water concentrations. Should the water concentration fall below 1 gal./min./sq. ft. of tower area, it will be necessary to employ the next size higher tower. This is because in extremely light water concentrations the water will not be uniformly distributed and the performance as predicted by the accompanying curves will not be achieved.

3 gal./min./sq. ft. Necessitate Size Lower

Should the water concentration exceed 3 gal./min./sq. ft. of tower area, it will then be necessary to choose the next size lower tower. The higher water concentrations tend to blanket the tower and will not allow sufficient air to pass through to accomplish the cooling shown on the curves.

Wet Bulb Temperature. Theoretically, a cooling tower cannot cool water to a temperature lower than the prevailing wet bulb temperature. Being limited by this fact, one is more interested in the economic approach of the cold water temperature to said temperature. Air has a greater capacity for absorbing heat at the higher wet bulb temperatures. At the lower wet bulb, air, in passing through the tower, must have a greater temperature rise to accomplish the same cooling. Therefore, to obtain the same approach at the lower wet bulb temperatures it is necessary to reduce the concentration.

Calculating Tower Size

To calculate the size of an atmospheric type cooling tower with effective width of 12 ft., the following general formula may be used:

$$L = \frac{GPM \times W}{C \times 12 \times Cw \times Ch}$$

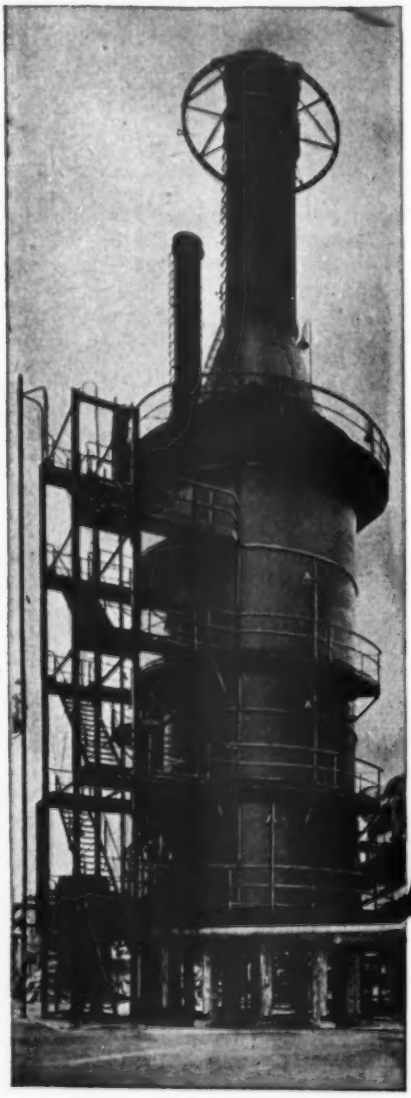
where:

L = length of tower in ft.,
GPM = quantity of water in gal. per min.,
W = wind correction factor,
C = concentration of water per sq. ft. of cooling tower area,
Cw = wet bulb correction factor, and
Ch = tower height correction factor.

To illustrate the application of the above formula and the charts previously presented in this article to the design of atmospheric cooling towers, a series of five problems are given below. In addition to the symbols explained above, the following are also used in these problems:

T_1 — inlet temperature.
T_2 — outlet temperature.
$(T_1 - T_2)$ — temperature range.
Twb — wet bulb temperature.
$(T_2 - Twb)$ — approach to wet bulb temperature.

PROBLEM NO. 1: Determine the length of 35 ft. high tower required to



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cool 1500 gpm from 90 to 75° F. with 70° F. wet bulb temperature and a 3 mph wind.

From these conditions we know that the approach $(T_2 - Twb) = 5°$ F. and the range $(T_1 - T_2) = 15°$ F. From Fig. 2, it is found that these two values require a concentration of $C = 1.17$. The correction factors, Ch, Cw and W will be equal to one, as shown on their respective correction factor curves, because Fig. 2 was based upon values equal to those given in the problem. Substituting the corresponding values in the above formula we find that a tower 107 ft. long is required.

PROBLEM NO. 2: Let us take the same conditions that exist in Problem No. 1 and see what the effect would be when the wind velocity is increased to 5 mph. From Fig. 5, when the wind velocity is 5 mph, $W = .80$. Substituting this value for W in the formula, we find that an 85.3 ft. long tower is required.

PROBLEM NO. 3: Again assume the same conditions as Problem No. 1, except that due to space considerations it is necessary to have a 51 ft. high tower. From Fig. 4, when tower height is 51 ft., $Ch = 1.63$. Substituting the new Ch in the formula we find that a 65½ ft. long tower is required.

PROBLEM NO. 4: Assume the conditions of this problem are identical to those of Problem No. 1, except that water has to be cooled from 85 to 70° F. and the wet bulb temperature is 65° F. From Fig. 3, when the wet bulb temperature is 65° F., $Cw = .86$. Substituting this factor in the general formula we find tower length to be 124 ft.

PROBLEM NO. 5: Once a tower is installed, the problem often arises of determining what cold water temperature one can expect under conditions differing from those for which the tower was designed. For example, let us take the tower calculated for Problem No. 1. This tower is 35 ft. high, 12 ft. wide, and 107 ft. long. What cold water temperature, T_2, can be expected when the wet bulb temperature is 60° F., wind velocity 4 mph, cooling range 15° F., and water circulation 2000 gpm?

The wet bulb temperature correction factor Cw from Fig. 3 is .71. The wind velocity correction factor W from Fig. 5 is .875. By substituting those values in the general formula and solving for water concentration, we find:

$$C = \frac{2000 \times .875}{107 \times 12 \times .71 \times 1}$$

$$= 1.92 \text{ gal./sq. ft.}$$

Turning to Fig. 2, we find that when the cooling range is 15° F. and the water concentration is 1.9, the approach to the wet bulb temperature is 9° F. This means that the cold water temperature will be 60° F. + 9° F., or 69° F.

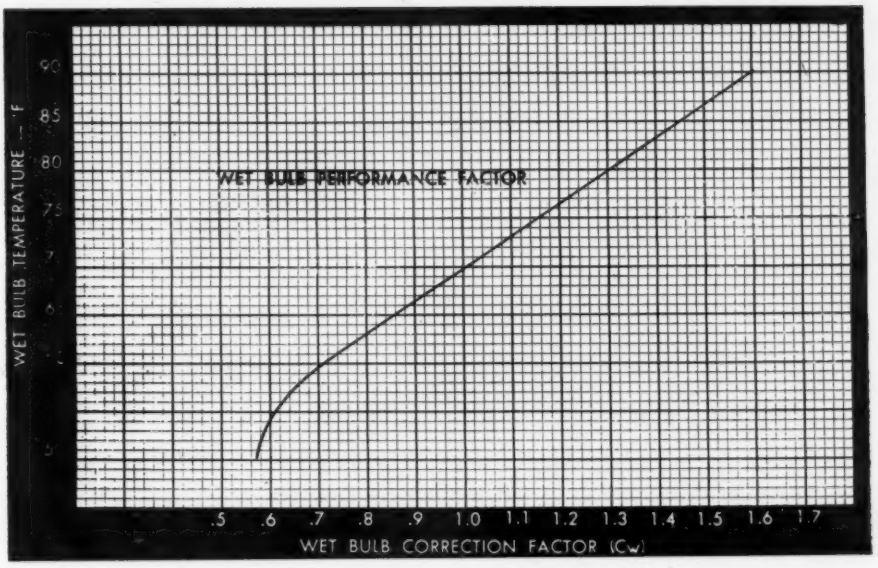

Fig. 3—Wet bulb performance factor

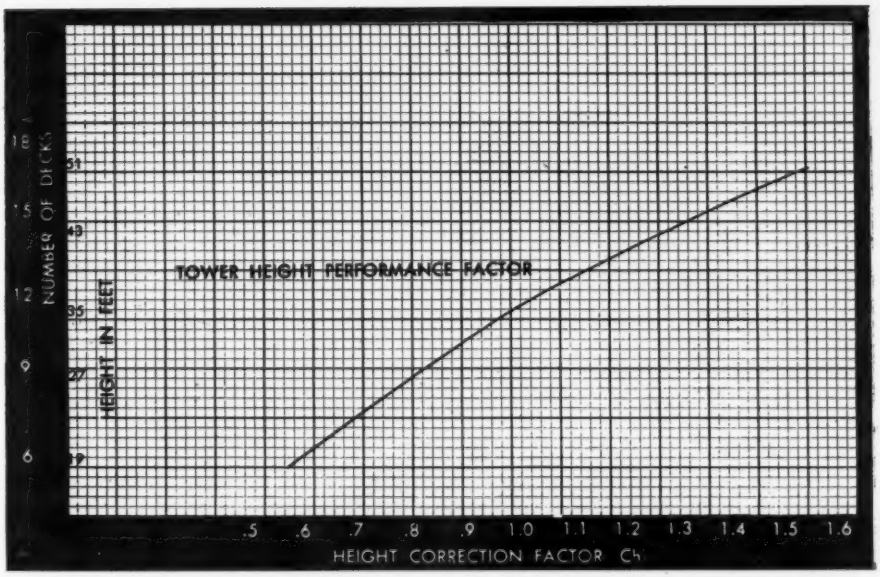

Fig. 4—Tower height for performance factor

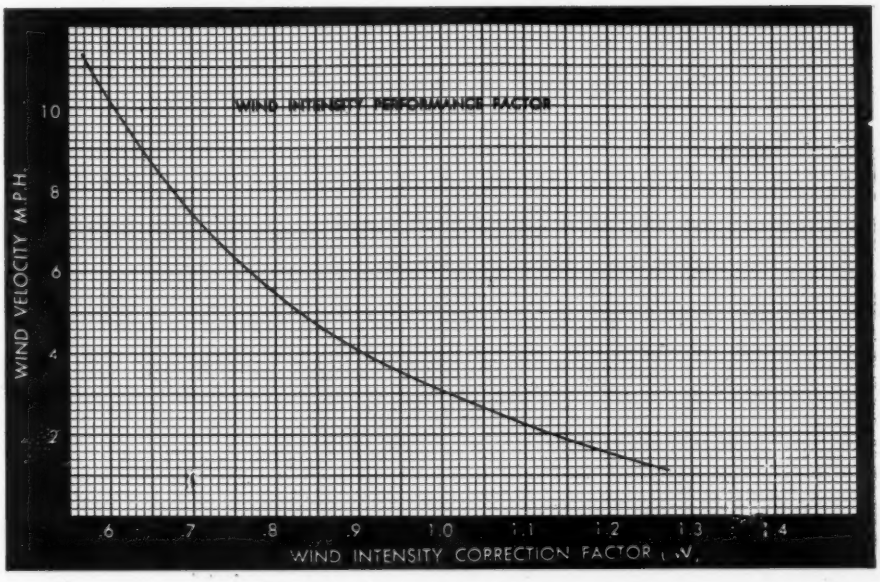

Fig. 5—Wind intensity performance factor

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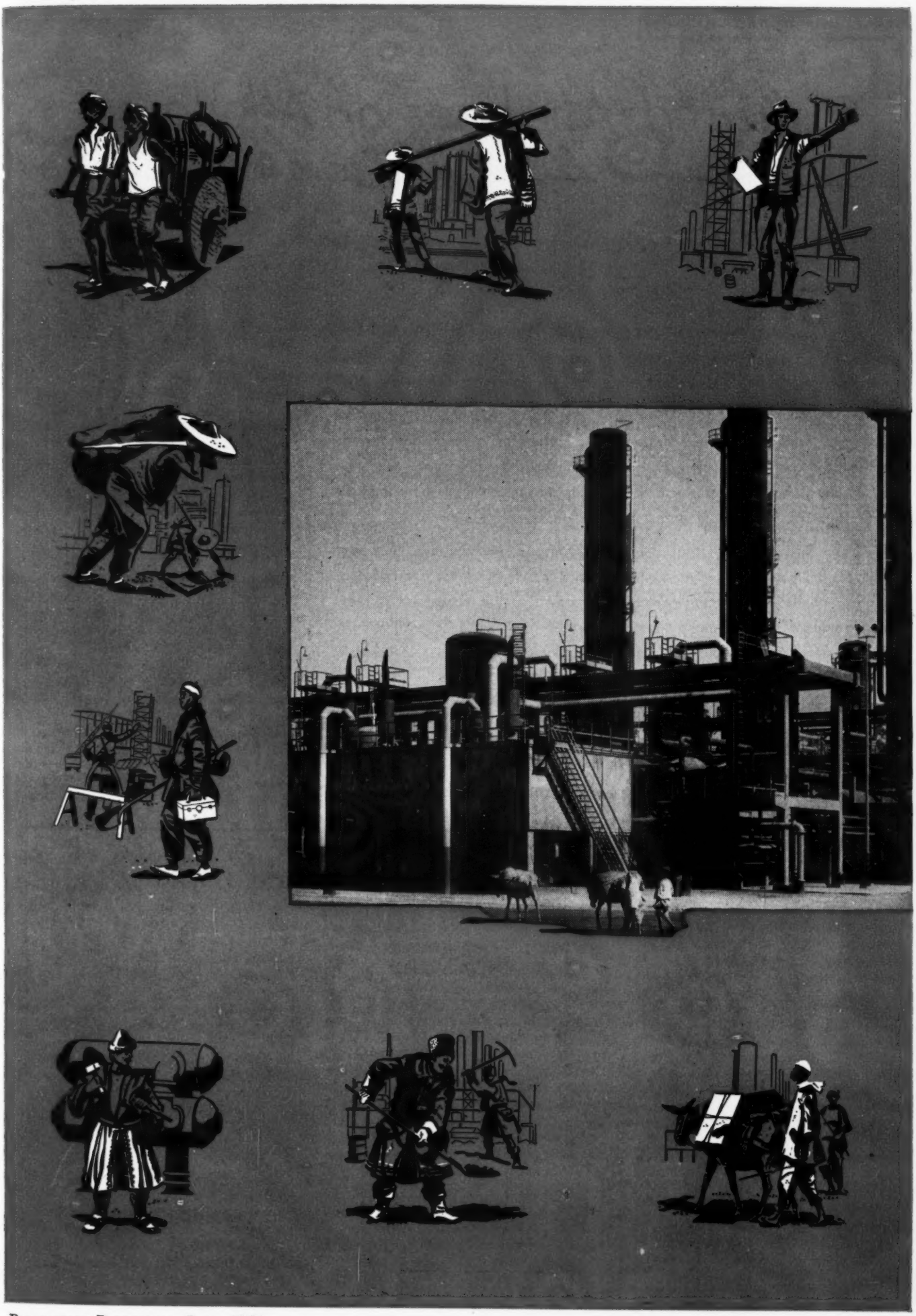

Infrared Analyses of Alkylates

And Correlation of Alkylate Composition with Motor Tests

By GLENN M. WEBB and WILLIAM S. GALLAWAY
Universal Oil Products Co.

Infrared spectrometric methods have been employed by Universal Oil Products for analyzing alkylates and determining their chemical composition. Last month the authors described the technique developed and how it is used (*PETROLEUM PROCESSING*, May 1947, pg. 356).

This month they present data obtained using their new method and showing the composition of a group of HF and H_2SO_4 alkylates. As a result of this data it is possible to make comparisons between the chemical composition of an alkylate and its engine performance.

Their findings show that the most pronounced difference between alkylates produced by the two methods is that the HF produces nearly twice as much of the 2,2,4-trimethylpentane isomer. Another conclusion is that the amount of the trimethylpentanes increases and that of the dimethylhexanes decreases approximately linearly as the octane number of the depentanized product increases.

THE preceding section of this paper describes in some detail the techniques that are used in analyzing alkylates for the purpose of determining the type and amount of the individual hydrocarbons present. During the past few years these methods have been used to analyze several different alkylates that were of interest owing to variation in the methods used in preparing them. Since engine performance data were also obtained in these samples, they afford a good opportunity to study the relationships between alkylate composition and engine performance as indicated by the F-2 ASTM octane number. All of the alkylates originating at Universal Oil Products which are discussed in this paper were made with hydrogen fluoride as the catalyst.

Recently a large quantity of data relating to alkylate composition and octane rating was presented before the Division of Refining of the American Petroleum Institute at the 26th Meeting of the Institute, November 12, 1946[9, 10]. The analyses were reported by F. D. Rossini of the National Bureau of Standards. They were made by means of analytical distillations conducted in high efficiency columns with high reflux ratio, utilizing accurately measured values of the boiling points and refractive indices of the distillate fractions. This work covered the compositions of alkylates made for the main part with sulfuric acid as the catalyst, although a few samples were included wherein hydrogen fluoride was the catalyst.

Part Two

This is the second half of the article "Infrared Analyses of Alkylates". The first half appeared in the May 1947 issue of PETROLEUM PROCESSING, pg. 356.

Taken together, these two sets of data permit an accurate comparison to be made of the compositions of the alkylates produced with the two catalysts, hydrogen fluoride and sulfuric acid. They also make it possible to determine the changes in alkylate composition that are brought about by changing process conditions. In the discussion that follows, attention will be directed to a comparison of the compositions of the alkylates produced by the two catalysts, and the effects of variations in alkylate compositions on their engine performance.

In view of the fact that totally different methods of analysis were used in analyzing the samples at the National Bureau of Standards and at U.O.P., it is of interest to know if the two methods yield equally reliable results. One comparison has been made. In this test a portion of N.B.S. alkylate No. 27, which had been analyzed by Dr. Rossini using his method of extended distillation, was analyzed (by the writers) by our own infrared spectrometric method. Although the results of this comparison have already been published[10] they are given in Table 5 for reference. It is seen that there is excellent agreement between the two methods. It is safe to conclude, then, that both analytical methods yield results of the same order of accuracy.

Results

Complete analyses of 16 alkylates, all made with HF as the catalyst, are summarized in Table 6. All of these samples were made from C_4 olefins and isobutane with the exception of sample No. 4, which was made with propylene as the olefin. Casual examination of these data shows that in nearly all cases approximately three-fourths or more of the entire alkylate falls within the C_8 range. It was therefore felt at the outset that if any correlations between composition and engine performance were possible, they would probably involve the C_8 hydrocarbons. As will

TABLE 5—Comparison of N.B.S. and U.O.P. Analyses of Alkylate No. 27

Component	U.O.P.	N.B.S.
n-C_4	0.25	...
i-C_5	8.20	8.3
n-C_5	0.43	0.6
2.2-Me_2C_4	0 02	0.0
2,3-Me_2C_4	4.72	4.7
2-MeC_5	0.98	1.1
3-MeC_5	0.46	0.4
2,2-Me_2C_5	0.00	0.2
2,4-Me_2C_5	3.56	3.4
2,2,3-Me_3C_4	0.28	0.2
2,3-Me_2C_5	2.44	2.3
2-MeC_6	0.10	0.3
3-MeC_6	0.06	
2,2,4-Me_3C_5	24.40	24.3
2,2-Me_2C_6	0.10	0.2
2,5-Me_2C_6	4.46	6.6
2,4-Me_2C_6	2.76	
2,2,3-Me_3C_5	1.34	1.2
2,3,4-Me_3C_5	12.38	13.0
2,3,3-Me_3C_5	12.49	12.3
2,3-Me_2C_6	2.56	3.0
3,4-Me_2C_6	0.73	0.4
2,2,5-Me_3C_6	4.25	4.5

TABLE 6—Composition of HF Alkylates

		Sample No.															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
ASTM Octane Number		88.0	88.7	89.7	90.2	90.8	90.8	90.8	91.0	91.2	91.5	91.8	92.2	92.7	93.0	93.0	94.2
Olefin		C_4	C_4	C_3	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4	C_4
Component (Vol.-%)	B.P. °C.																
Isopentane	27.9	..	..	1.6	..	..	7.5	0.6	0.8	..	1.5	0.4	0.0	0.2	0.0	9.5	1.2
2, 2-Me_2C_4	49.7	0.3	0.3	0.1	..	..	..	0.1	0.1	..	0.1	0.4	0	0.2	0	0.1	
2, 3-Me_2C_4	58.0	4.5	2.3	2.3	..	..	3.7	2.9	3.2	..	2.7	3.3	4.0	3.3	3.1	1.9	2.6
2-MeC_5	60.3	1.8	..	..	..	..	1.0	..	..	..	..	..	..	..	..	..	..
3-MeC_5	63.3	0.8	..	0.7	..	..	0.5	..	..	..	..	..	..	..	..	..	..
2, 4-Me_2C_5	80.5	5.5	6.1	19.0	..	..	4.3	4.8	5.0	1.3	4.7	3.9	5.0	4.1	4.0	2.9	4.3
2, 2, 3-Me_3C_4	80.9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2, 3-Me_2C_5	89.8	2.5	2.2	37.2	..	..	2.6	2.1	2.5	0.9	3.2	0.8	1.4	1.0	1.2	1.5	1.2
MeC_6	90-92	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2, 2, 4-Me_3C_5	99.2	29.0	35.0	18.9	37.2	36.8	34.0	39.8	39.4	38.6	40.4	44.9	42.7	46.3	46.6	39.2	53.7
Me_2C_6	109	16.6	18.6	1.9	7.3	11.7	10.8	14.1	13.5	12.8	13.3	12.1	11.2	8.9	11.6	6.6	7.0
2, 2, 3-Me_3C_5	109.8	1.8	1.0	..	..	0.4	0.4	1.2	1.4	2.8	1.2	..	..	..	..	..	0.7
2, 3, 4-Me_3C_5	113.5	8.5	9.2	5.5	12.4	12.9	11.9	12.7	13.1	10.7	13.6	16.9	19.1	20.5	15.3	17.3	13.0
2, 3, 3-Me_3C_5	114.8	7.2	7.6	2.6	6.6	6.3	5.8	6.9	7.6	11.1	7.7	8.7	6.7	7.3	9.0	8.2	8.6
2, 3-Me_2C_6	115.6	3.7	4.3	0.1	2.5	3.4	3.1	3.6	3.6	1.6	3.7	..	..	..	..	2.0	1.4
Higher Boiling	116	17.8	13.4	10.1	..	..	14.4	11.3	9.8	20.2	7.6	8.6	9.9	8.2	9.2	2.5	6.3

TABLE 7—U.O.P. Data on HF Alkylates
Depentanized Basis

		Volume %						F-2	Vol. %
No.	Olefin	2,2,4-Me_3C_5	2,4-&2,5-Me_2C_6	2,2,3-Me_3C_5	2,3,4-Me_3C_5	2,3,3-Me_3C_5	2,3-Me_2C_6	Octane Number	Total C_8
2	C_4	29.0	16.6	..	8.5	7.2	3.7	88.0	65.0
3	C_4	35.0	18.6	..	9.2	7.6	4.7	88.7	75.1
4	C_3	19.2	1.9	..	5.6	2.6	0.1	89.7	29.4
5	C_4	37.2	7.3	..	12.4	6.6	2.5	90.2	66.0
6	C_4	36.8	11.7	0.4	12.9	6.3	3.4	90.8	71.5
7	C_4	34.0	10.8	0.4	11.9	5.8	3.1	90.8	66.0
8	C_4	40.1	14.2	1.2	12.8	7.0	3.6	90.8	78.9
9	C_4	39.7	13.7	1.4	13.2	7.7	3.6	91.0	79.3
10	C_4	38.6	12.8	..	10.7	11.1	1.6	91.2	74.8
11	C_4	41.2	13.5	1.3	13.8	7.8	3.8	91.5	81.4
12	C_4	44.9	12.1	..	16.9	8.7	3.0	91.8	85.6
13	C_4	42.7	11.2	..	19.1	6.7	3.0	92.2	82.7
14	C_4	46.3	8.9	..	20.5	7.3	3.0	92.7	86.0
15	C_4	46.6	11.6	..	15.3	9.0	3.0	93.0	85.5
16	C_4	44.8	7.5	..	19.8	9.4	3.0	93.0	84.5
17	C_4	54.4	7.1	..	13.2	8.7	1.4	94.2	84.8

be shown presently, this is actually the case. Hence, for convenience, the data of Table 6 have been retabulated in Table 7, giving only the percentages of the C_8 components, based on the C_5 free alkylate.

Similarly, Table 8 lists pertinent data from the two papers already cited[9, 10]. These data also include only the C_8 members, referred to the depentanized alkylate. While most of these samples were made with sulfuric acid as the catalyst, three of them were made with hydrogen fluoride. The latter include one alkylate each, made by alkylating C_3, C_4, and C_5 olefins with isobutane. The sulfuric acid alkylates include one C_3, four C_4, and four C_5 alkylates, all prepared from the corresponding olefin and isobutane.

This mass of data was analyzed by plotting the vol.-% of each of the C_8 isomers found in reasonable quantity versus the ASTM octane number of the entire sample. Such plots for the 2,2,4-, 2,3,4-, and 2,3,3-trimethylpentanes and the 2,4- and 2,5-dimethylhexanes are shown in Figs. 3 to 6 inclusive. The data on the C_4 alkylates for all of these isomers are shown in summary form in Fig. 7.

These curves show clearly that the principal difference between HF and H_2SO_4 alkylates is that the HF produces nearly twice as much of the 2,2,4-trimethylpentane (isooctane) as does H_2SO_4.

Another interesting feature of the curves is that, for both catalysts, the concentration of the trimethylpentanes increases while the concentration of the dimethylhexanes decreases as the octane number of the product rises.

The final item to which attention should be drawn is the amount of the C_8 isomers produced when either C_3 or C_5 olefins are alkylated with isobutane. In general, the C_3 olefin produces the least amounts of these isomers for a given octane number product, while C_5 olefins yield amounts intermediate between C_3 and C_4 olefins. The probable mechanism of the formation of octanes when these olefins are used was described recently by L. Schmerling[11].

A cursory glance at the data given in Tables 6 to 8 shows that the engine performance of alkylates improves as the fraction of the alkylate occurring in the C_8 cut increases. In Figs. 8 and 9 are shown parts of the vol.-% of C_8 material in the C_5 free alkylates vs ASTM octane

TABLE 8—N.B.S. Data on H_2SO_4 & HF Alkylates
Depentanized Basis

			Volume %						F-2	Vol. %
No.	Cat.	Olefin	2,2,4-Me_3C_5	2,4-&2,5-Me_2C_6	2,2,3-Me_2C_5	2,3,4-Me_3C_5	2,3,3-Me_3C_5	2,3-Me_2C_6	Octane Number	Total C_8
17	HF	C_3	16.3	4.0	1.1	3.4	3.9	0.9	87.5	29.6
20	H_2SO_4	C_3	7.8	2.5	0.8	2.5	3.2	1.2	88.7	18.0
13	HF	C_4	41.7	13.4	2.9	9.4	10.0	6.2	91.1	83.6
9	H_2SO_4	C_4	25.9	7.9	1.7	16.4	12.1	4.2	91.9	68.2
10	H_2SO_4	C_4	26.8	8.3	1.6	19.2	14.9	2.3	92.3	73.1
24	H_2SO_4	C_4	35.5	3.4	2.0	24.0	25.2	2.4	96.7	92.5
27	H_2SO_4	C_4	26.7	7.2	1.3	14.3	13.5	3.3	92.2	66.3
14	HF	C_5	24.2	3.9	0.7	5.4	4.2	1.2	87.1	39.6
7	H_2SO_4	C_5	13.1	4.3	0.9	6.6	4.5	1.1	88.9	30.5
12	H_2SO_4	C_5	12.4	4.1	0.7	4.2	7.0	0.2	87.7	28.6
22	H_2SO_4	C_5	21.7	3.7	0.7	9.4	9.5	0.9	92.1	45.9
23	H_2SO_4	C_5	17.2	3.9	0.8	6.4	7.1	0.9	90.7	36.3

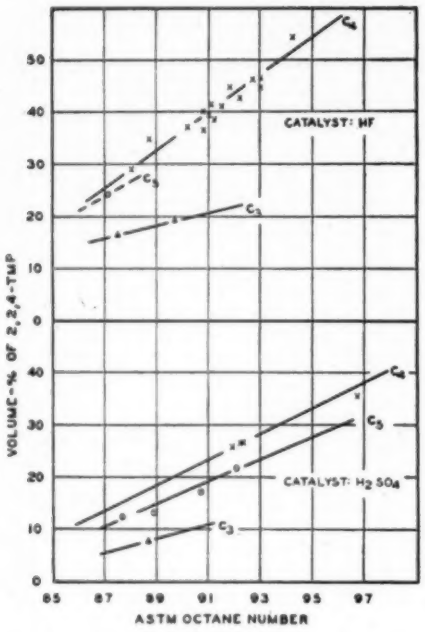

Fig. 3—Vol.-% 2.2.4-trimethylpentane in depentanized alkylate versus ASTM octane number

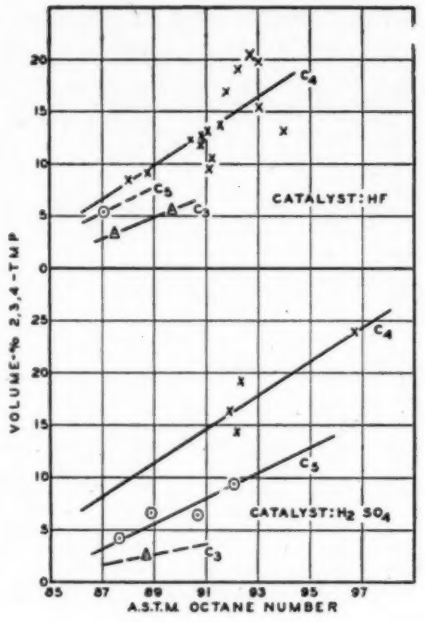

Fig. 4—Vol.-% 2.3.4-trimethylpentane in depentanized alkylate versus ASTM octane number

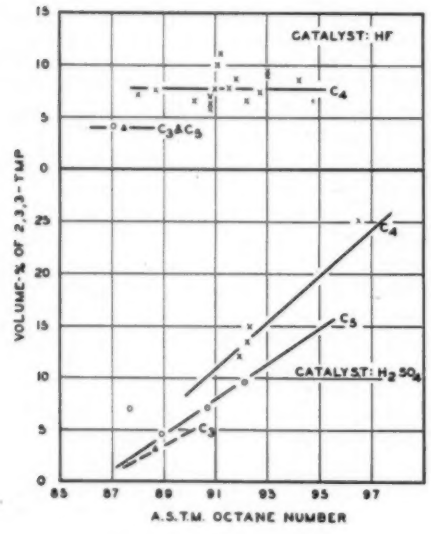

Fig. 5—Vol.-% 2.3.3-trimethylpentane in depentanized alkylate versus ASTM octane number

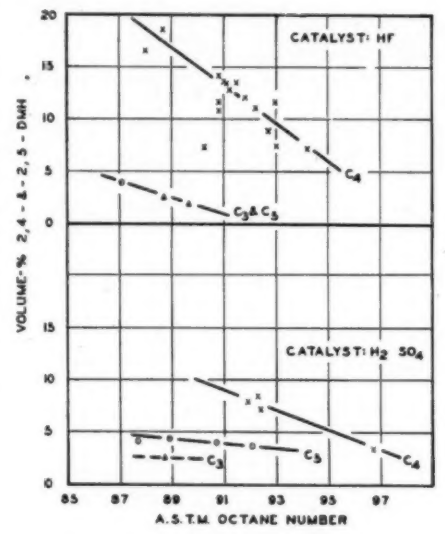

Fig. 6—Vol.-% 2.4- & 2.5-dimethylhexane in depentanized alkylate versus ASTM octane number

number for both HF and H_2SO_4 products.

Fig. 8, which contains all of the data on alkylates made with H_2SO_4, presents a clear cut relationship between the C_8 material and the ASTM clear octane number. Fig. 9, which is a similar plot for the alkylates made from HF, displays the same trend. The most interesting features of these plots are:

(1) For a given octane number product, the proportion of C_8 material is greatest for C_4 and least for C_3 olefins.

(2) For a given octane number product, C_4-HF alkylates contain 15-20% more C_8 material than do the C_4-H_2SO_4 alkylates. This is usually due to the tendency of the HF to produce large proportions of 2,2,4-trimethylpentane.

Stability of Alkylate

As part of another study, one alkylate was contacted with hydrofluoric acid for times varying from 0 to 576 hrs. The alkylates recovered from these tests were analyzed and the data proved to be of sufficient interest that they are included here.

These tests were performed by mixing 880 ml. of alkylate with 175 ml. of hydrogen fluoride and storing the mixture at 150° C. in a sealed autoclave. Three such mixtures were stored and analyzed after 360, 384 and 576 hrs. The fresh untreated material was also analyzed. The results of the tests are summarized in Table 9.

The nature of the changes that took place as a result of the treatment of the alkylate with HF can be seen more clearly if only the C_8 hydrocarbons are considered. For this purpose, the composition of the C_8 fractions is shown in Table 10. Included in this table in the last column are the equilibrium isomerization concentrations of seven of the C_8 isomers. These were taken from the paper by Prosen, Pitzer and Rossini[12]. These data are displayed graphically in Figs. 10 and 11.

The reactions that seem to be occurring here include cracking, realkylation, and isomerization. It is seen that the 2,2,4- and 2,3,4-trimethylpentanes are the least stable of all those present. While the equilibrium concentration of the 2,3,3-trimethylpentane is undoubtedly low, it decomposes at a much slower rate than the 2,2,4- and 2,3,4-trimethylpentanes, as is evidenced by the fact that its concentration appears first to increase before decreasing. The fact that the 2,2,3-trimethylpentane also exhibits an increase in concentration shows that it too is one of the more stable trimethylpentanes at this temperature. It is unfortunate that more of this compound is not formed in the alkylation process because it does possess unusually good engine characteristics.

The dimethylhexanes and methylheptanes all showed large increases in concentrations as the time of treatment increased.

These observed changes in alkylate composition are qualitatively consistent with what would be expected from the

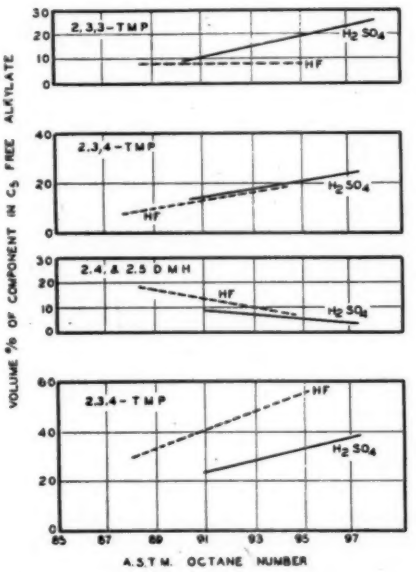

Fig. 7—Comparison of compositions of HF and H_2SO_4 C_4 alkylates

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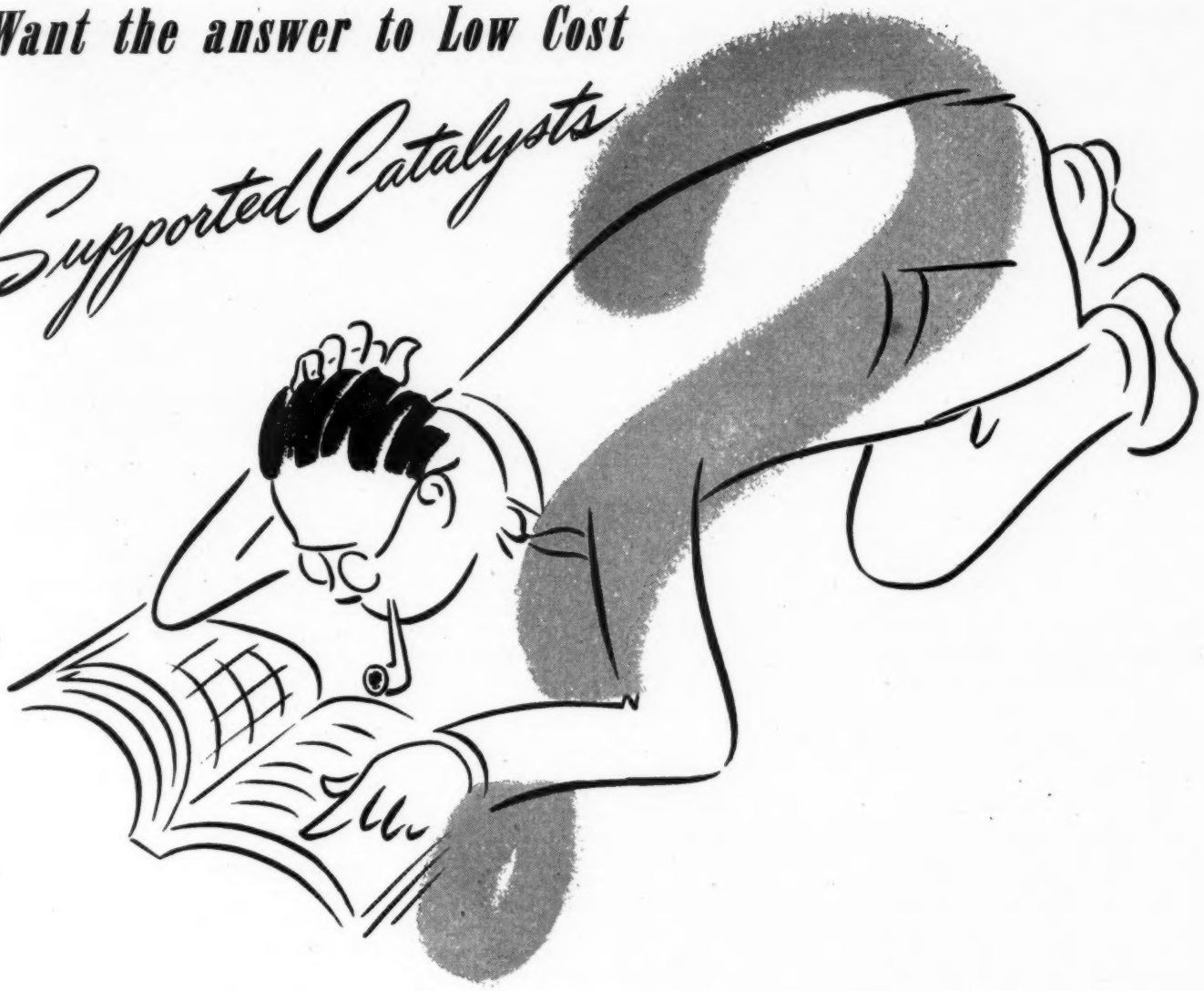

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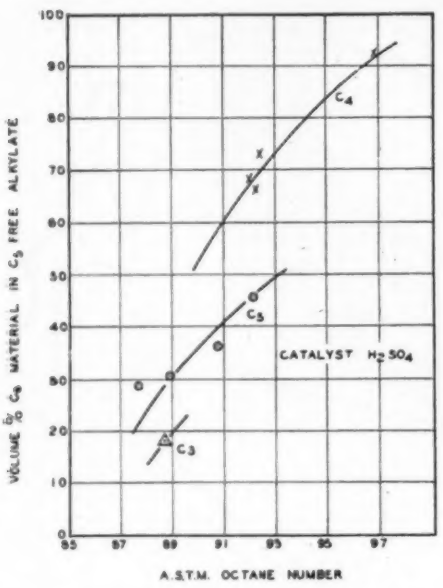

Fig. 8—Relation between octane number and amount of C_8 material produced (H_2SO_4 catalyst)

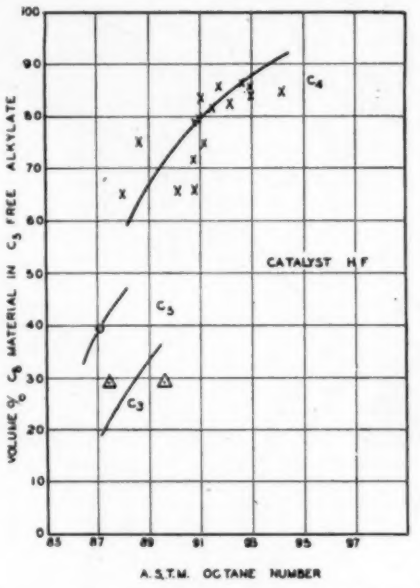

Fig. 9—Relation between octane number and amount of C_8 material produced (HF catalyst)

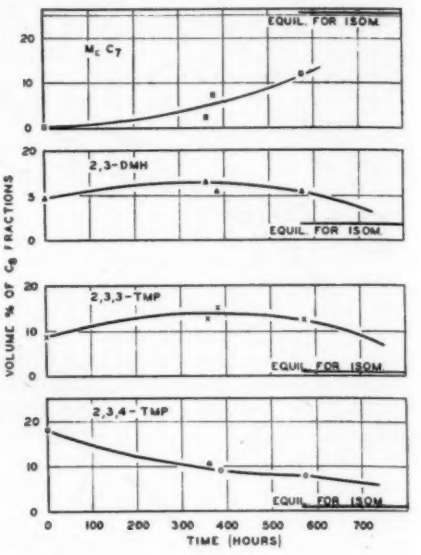

Fig. 10—Variation in alkylate composition (C_8 cut) with time of contact with HF

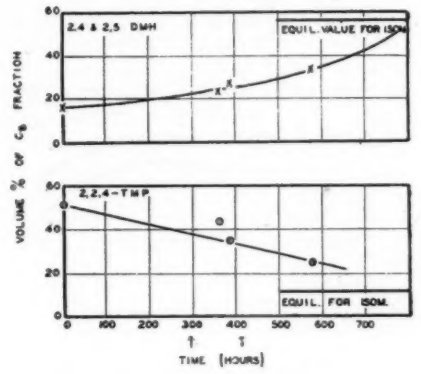

Fig. 11—Variation in alkylate composition (C_8 cut) with time of contact with HF

theoretical isomerization equilibrium data already cited.

Conclusion

This paper summarizes the methods used in the Riverside Laboratories of the Universal Oil Products Co. for the analysis of alkylates. The techniques involve rough prefractionation of the sample into a series of cuts followed by infrared absorption measurements on each cut. By these methods, 16 alkylates made with HF as catalyst have been analyzed.

These data, taken together with similar analytical data obtained on a group of sulfuric acid and hydrogen fluoride alkylates by Project 6 of the American Petroleum Institute at the National Bureau of Standards, permit correlations to be made between the engine performance and the composition of the individual hydrocarbons in the alkylate, particularly those in the C_8 range. The results of the correlation show that the largest difference between HF and H_2SO_4 alkylates is that the HF produces much more—roughly 20% by volume—of the 2,2,4-trimethylpentane isomer. It is also concluded that the amount of the trimethylpentanes increases and that of the dimethylhexanes decreases approximately linearly as the octane number of the depentanized product increases.

It has also been shown that when alkylate is contacted for long periods of time with hydrogen fluoride the alkylate suffers appreciable decomposition and isomerization. The 2,2,4- and 2,3,4-trimethylpentanes are the least stable of the trimethylpentanes. Large increases in the amounts of dimethylhexanes and methylheptanes were also observed.

TABLE 9—Decomposition of Alkylate by HF

(Temp. = 150°F; 880 ml. Alkylate & 175 ml. HF Charged to Bomb)

Time of Test (Hrs.)	0	360	384	576
Compound	Vol. %			
i-C_5	7.5	8.8	7.5	4.4
2,3-Me_2C_4	3.7	2.7	2.8	2.6
2-MeC_5	1.0	2.2	3.1	6.3
3-MeC_5	0.5	1.4	2.3	2.1
2,4-Me_2C_5	4.3	4.2	4.6	3.3
2,2,3-Me_3C_5	0	0.3	0.4	0.3
2,3-Me_2C_5	2.6	2.2	2.0	2.0
MeC_6	0	1.0	2.3	3.1
2,2,4-Me_3C_5	34.0	16.4	9.7	5.4
2,4- & 2,5-Me_2C_6	10.8	8.8	7.5	7.3
2,2,3-Me_3C_5	0.4	0.4	0.7	0.8
2,3,4-Me_3C_5	11.9	3.9	2.5	1.7
2,3,3-Me_3C_5	5.8	4.8	4.3	2.8
2,3-Me_2C_6	3.1	2.4	1.5	1.2
2- & 3-MeC_7	0	0.8	2.0	2.6
C_9+	14.4	39.7	46.8	54.1

TABLE 10—Composition of C_8 Fractions

Time of Test (Hrs.)	0	360	384	576	Isomerization Equilibrium Concentration
Compounds	Vol. %				
2- & 3-MeC_7	0	2.1	7.1	11.9	18.7
2,3-Me_2C_6	5.8	6.4	5.3	5.5	1.6
2,3,3-Me_3C_5	8.8	12.8	15.3	12.8	1.0
2,3,4-Me_3C_5	18.0	10.4	8.8	7.8	1.2
2,4- & 2,5-Me_2C_6	16.4	23.5	26.6	33.5	35.6
2,2,4-Me_3C_5	51.5	43.7	34.4	24.8	6.7
2,2,3-Me_3C_5	0.6	1.1	3.7	2.5	1.5

It has also been shown that when alkylate is contacted for long periods of time with hydrogen fluoride the alkylate suffers appreciable decomposition and isomerization. The 2,2,4- and 2,3,4-trimethylpentanes are the least stable of the trimethylpentanes. Large increases in the amounts of dimethylhexanes and methylheptanes were also observed.

References

(9) Glasgow, Jr., A. R., Streiff, A. J., Willingham, C. B., and Rossini, F. D., *Proc. Am. Petroleum Inst.*, 26, in process (1946).

(10) Gould, D. W. and Field, H. W., *Proc. Am. Petroleum Inst.*, 26, in process (1946).

(11) Schmerling, L., *J. Am. Chem. Soc.*, 67, 1778 (1945); 68, 275 (1946).

(12) Prosen, E. J., Pitzer, K. S., and Rossini, F. D., *J. Research Nat. Bur. Standards*, 34, 255 (1945).

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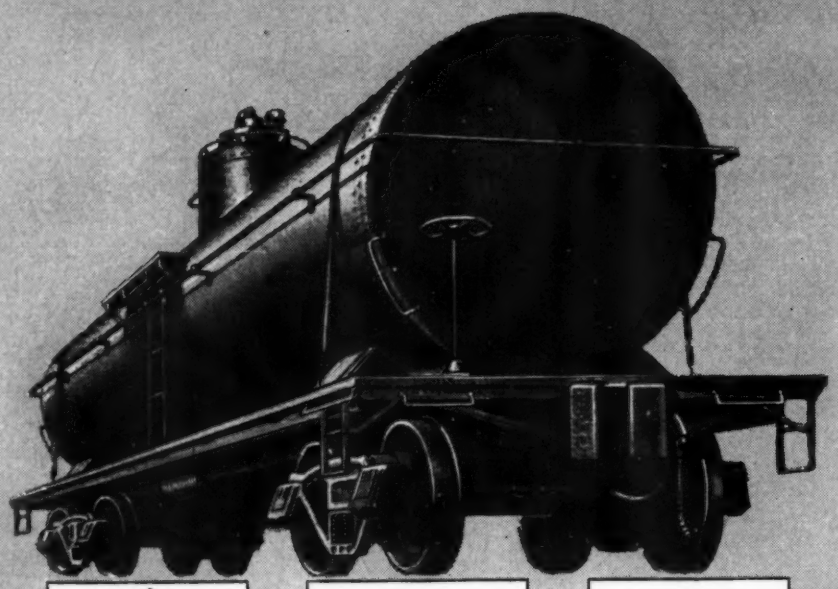

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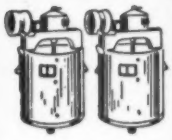

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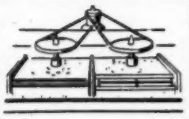

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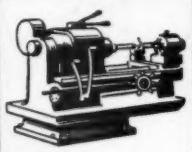

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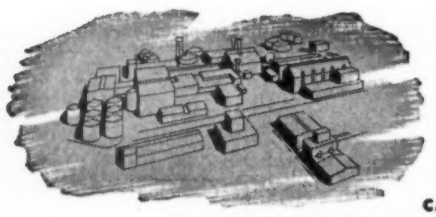

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New Design for Heat Exchangers Relieves Strain on Tube Sheet

By S. KOPP and G. B. FARKAS

American Locomotive Co., Alco Products Division

CONSIDERATION of the use of appropriate materials and design is necessary for heat exchangers, handling fluids at a temperature greater than 650° F. The choice of the material will be influenced by its strength and corrosion resistance at the high temperatures and also its adaptability for fabricating the component parts of the exchanger.

Heat exchangers of large shell diameter, operating at high temperatures and high pressures, may require special analysis of temperature stresses to assure satisfactory operation. The temperature gradient increases with increasing wall thickness and when the temperature gradient across a component part is high, the resulting stress may exceed the design or yield stress of the material.

If such a condition exists, the designer must resort to cooling or insulating the part, reinforcing it in some way, or reducing the size of the exchanger. One or more of these methods have been used in numerous heat exchangers that have given satisfactory service.

The shell and multi-tube heat exchanger is generally used as standard equipment by most refiners although several other types are available for specific applications(1). In buying this equipment refiners generally specify that it be fabricated in accordance with the requirements of the API-ASME Code(2) and in some cases the ASME Code(3).

However, neither of these codes cover the design of the tube sheet and those refiners who do not specify the design procedure will accept the recommendations of the Tubular Exchanger Manufacturers Assn.'s Standards(4) on this point. Heat exchangers having tube sheets designed in accordance with TEMA recommendations will be acceptable for API-ASME and ASME stamping.

None of these authorities specify the method to be used in determining the metal temperature across the tube sheet. Gardner(5) published a method for determining the metal temperature gradient across the tube sheet from which the stresses may be calculated.

Fig. 1 shows the temperature and stress conditions versus tube sheet thickness, for the tube sheet of a high pressure waste heat boiler when the hot fluid was in the tubes. The tube sheet thickness calculated by the TEMA formula is 5½ in., which would be satisfactory for the average heat exchanger.

However, in this case we had a large diameter unit with a large temperature difference and the resulting stresses were excessive. By making provision in the design of this equipment to relieve the tube sheet of all pressure and superimposed loads and to keep it at the lowest

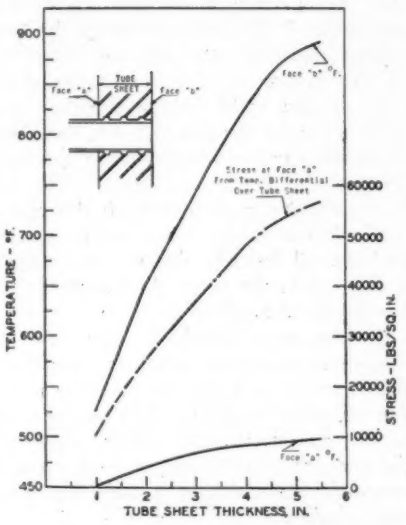


Fig. 1—Inside and outside temperatures, and stress in psi. versus tube sheet thickness

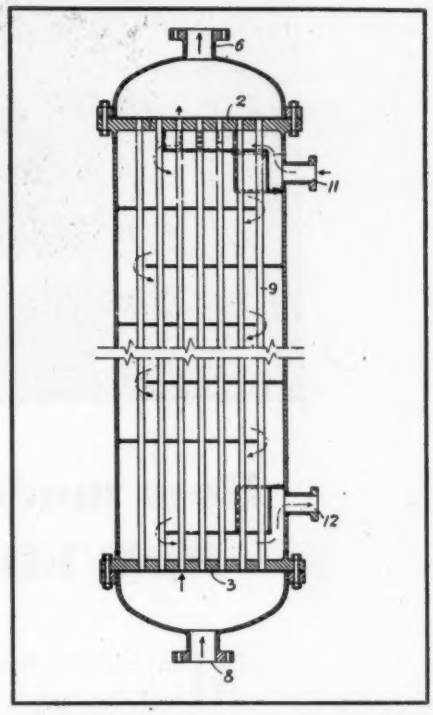
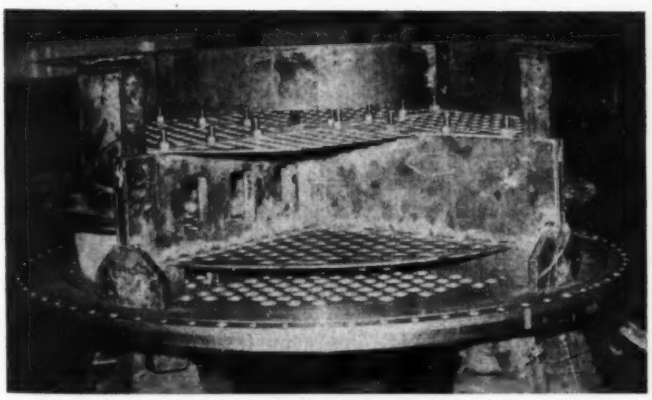
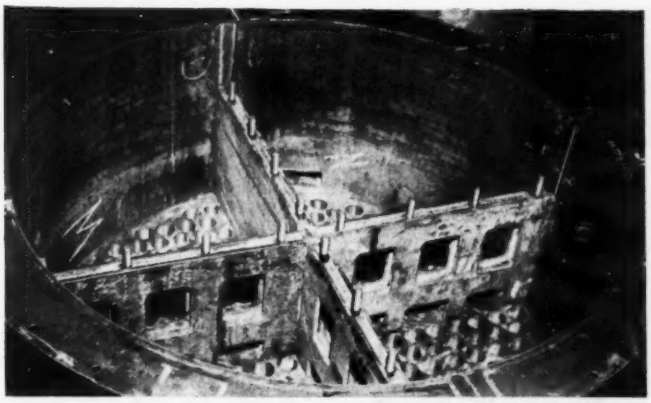


Fig. 2—Design of heat exchanger embodying additional baffles for cooling effect on tube sheets. Hot Fluid catalyst enters at 8, leaves at 6; cold oil enters shell at 11, leaves at 12



Assembly of tube sheet bridge and tube sheet cooling baffles on fixed tube sheet. Part of inner shell has been removed to show detail



Assembly of tube sheet bridge and lower part of inner shell on bottom tube sheet. Opening through which heated oil leaves exchanger is in upper right quadrant

uniform temperature, the actual tube sheet and thickness was made 1 in. These waste heat boilers have been in service for several years with complete satisfaction.

A design of heat exchanger incorporating the above provisions is shown in Fig. 2 and features of the lower or fixed tube sheet for a Fluid catalyst exchanger is shown in the photographs. This exchanger cools the catalyst from the regenerator with oil circulated through the shell, whereas others have evaporating water for cooling.

For this unit we used tube sheets having a thickness of 2¼ in. to minimize temperature stresses across the tube sheet. To carry the load of the tube bundle and the oil in the shell, the fixed tube sheet is braced with a structural steel bridge. This structural steel transfers the load to the edges of the tube sheet where it is readily carried on the shell structure. To provide for effective cooling of the tube sheet, the baffle design shown in the photographs was used(6).

The oil from the upper part of the shell flows through the opening in the top baffle. It then flows between the two baffles clockwise through the openings in the bridge members. At the right side of the solid bridge member the oil flows under the lowest baffle and then flows counterclockwise between the baffle and the fixed tube sheet. The oil leaves the inner shell through the opening adjacent to the shell outlet nozzle, and the oil flows to this nozzle through a channel in the inner shell section that has been removed.

By the use of this baffle arrangement, a positive sweeping action is assured at the inner or cold face of the tube sheet for effective cooling. The installation of the structural steel bridge permitted the tube sheet thickness to be kept at a minimum to maintain a safe temperature gradient.

Leakage at the joints or tube sheet failures are often traceable to warping resulting from temperature stresses. Sound engineering and design will invariably prevent failures and assure satisfactory service for heat exchangers operating under adverse conditions.

References

(1) "Heat Exchanger Design for Modern Refinery Processing", S. Kopp, *Petroleum Engineer*, June, 1945.

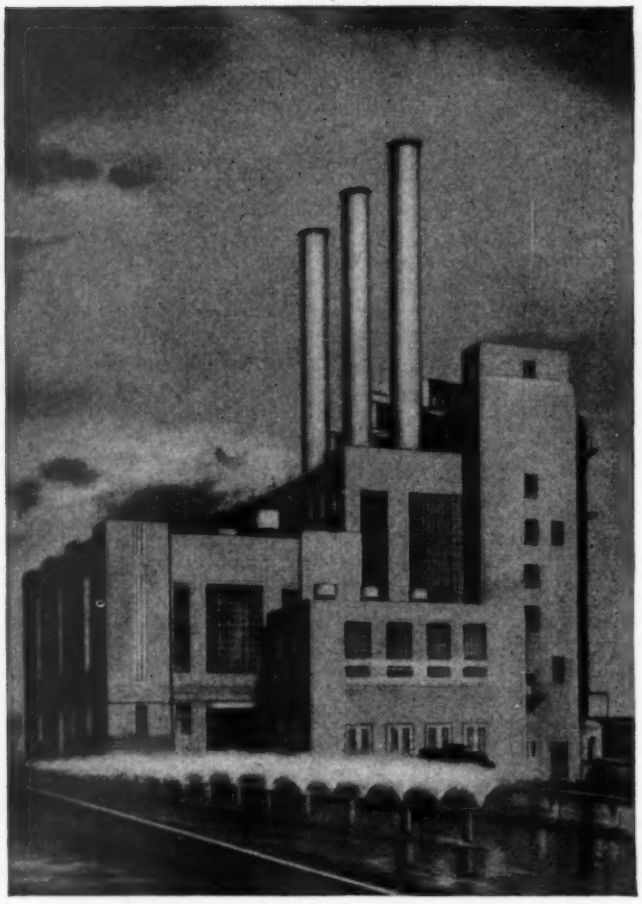
(2) "API-ASME Code for the Design, Construction, Inspection and Repair of Unfired Pressure Vessels for Petroleum Liquids and Gases", American Petroleum Institute and American Society of Mechanical Engineers, New York, (1943).

(3) "Rules for Construction of Unfired Pressure Vessels", American Society of Mechanical Engineers, New York, (1946).

(4) "Standards of the Tubular Exchanger Manufacturers Association", page 5, New York.

(5) "Heat Exchanger Tube Sheet Temperatures" by Karl A. Gardner, *The Refiner and National Gasoline Manufacturer*, March, 1942.

(6) U. S. Patent #2,411,097.



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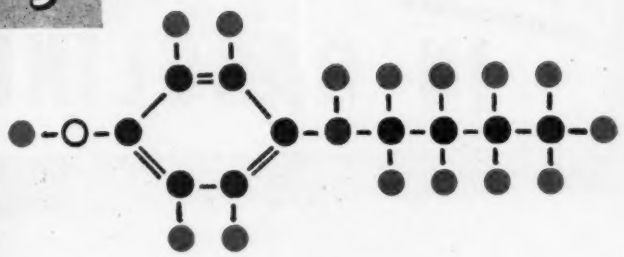

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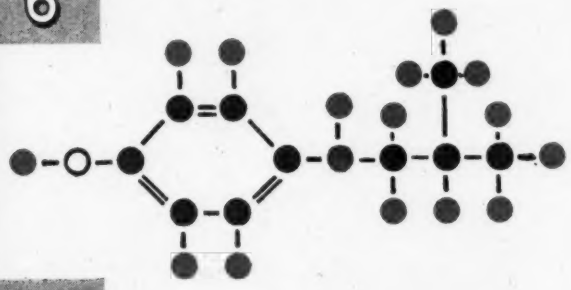

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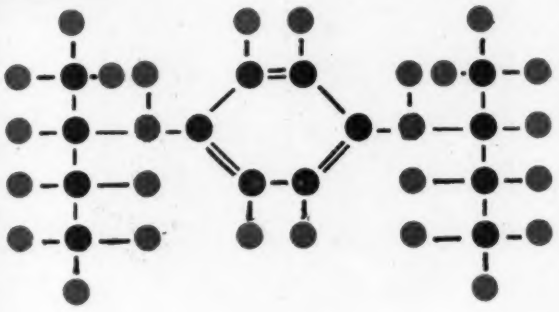

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By G. G. OBERFELL, Vice President
and R. C. ALDEN, Director of Research
Phillips Petroleum Co.

Presented before 26th Annual Convention, Natural Gasoline Association of America, Dallas, April 23-24, 1947.

Economic considerations and technological developments are creating for natural gasoline and distillate manufacturers the possibilities for greatly increased use of their products in motor fuels. It is recognized that the effect of catalytic cracking operations will tend toward lower volatility of gasolines so produced. However, it is shown that other factors will exert their influence to continue the trend toward increased volatility of average motor fuel, to which characteristic natural gasoline so greatly contributes.

The high-octane, high-vapor pressure natural gasolines constitute a large supply of high quality motor fuels, provided the direct use of these products in specialized equipment can be brought about. The processes which have been developed for the conversion and treatment of light hydrocarbons in straight refining are capable of application by natural gasoline and distillate manufacturers to increase the volume and scope of their motor fuel operations.

A brief introduction to this paper is omitted here, in which the authors recognize that supplying the liquefied petroleum gas market is a major phase of today's operations at natural gasoline and distillate plants. The most valuable large use of field butanes is in motor fuel, it is stated, and it is on this premise that LPG is omitted from further consideration.

FROM 1918 to 1946 inclusive the crude oil run to stills in the U. S. has amounted to 28.1 billion bbls. from which have been obtained 11.2 billion bbls. of gasoline. In 1918 the yield of gasoline was 25.3%, while in 1946 it was 39.4%. The highest annual yield of gasoline was 45.0% attained in 1939.

During this same period the natural gasoline industry, which now includes the distillate industry as a lusty twin brother, has produced 1.3 billion bbls., excluding the liquefied petroleum gas production. The production of natural gasoline has amounted to about one bbl. for every 25 bbls. of crude oil run to stills. In 1918 natural gasoline constituted 7.5% of the motor fuel supply and this percentage increased rather steadily to a high of 11.9% in 1930. From 1930 onward this percentage declined to a figure estimated to be about 7.0% in 1946. In 1946 the combined distillate and natural gasoline production constituted 11.6% of the motor fuel supply.

On the assumption that each barrel of natural gasoline and distillate produced has had the crude oil equivalency represented by the then current yield of motor fuel from crude oil the production of natural gasoline and distillate from 1918 to 1946 has been equivalent to 3,215,284,000 bbls. of crude oil. In 1946, if there had been no natural gasoline nor distillate production, the crude oil demand at refineries would have been 1.96 billion instead of the 1.68 billion bbls. per year that were run to stills, a difference of 13%.

As a matter of fact the contribution of natural gasoline to petroleum conservation is even greater than the 13% cited above, since natural gasoline is so great a factor in increasing the volatility and octane number of motor fuel, which improvements in turn have been

partly responsible for the increased basic economy of automotive performance.

The price structure of natural gasoline provides interesting relationships as to the real contribution of the volatile gasolines produced by natural gasoline and distillate operations. In Fig. 1 is shown the trends of the following factors from 1922 to date:

(a) Difference in price of Group III housebrand and 26/70 natural gasoline.
(b) Octane number of 4 major central states housebrand gasolines.
(c) Distillation temperature at 50% point, housebrand gasoline.
(d) Vapor pressure of housebrand gascline.

In spite of the fact that all of the quality factors of motor fuels have developed in the latter half of this period in a direction theoretically inimical to the relative price of natural gasoline, the relative price has remained practically constant. Of the several properties the change in octane numbers of motor fuel has been most pronounced. It is remarkable that the relative price of natural gasoline has remained so constant in the face of such striking increases in both the octane number and volatility of motor fuels. This state of affairs is all the more noteworthy when it is recalled that natural gasoline is sold on a vapor pressure basis which has the effect of bringing the lowest prices for the highest octane number products.

One conclusion that may be reached from Fig. 1 is that high volatility is the prime determinant of the relative value of natural gascline. It is, therefore, the best news in many years for the natural gasoline industry that catalytic oil cracking may reverse the trend of the past 15 years by making refinery produced gasolines less volatile.

The lower sales price of natural gasoline as shown in Fig. 1 is in part a reflection of its lower place value brought about by the need to ship the product to a refinery for blending with refinery produced gasolines. Nevertheless, the facts remain that in this apparently adverse market structure the natural gasoline industry has grown, has fostered outstanding research programs, and is going strong. The industry possesses the very great economic advantage of substantially lower manufacturing costs than prevail for the gasolines produced by complex refining processes.

In this brief economic review three valuable attributes of natural and distillate gasolines have been demonstrated:

First, without these products the need for crude oil to meet the nation's motor fuel demand would be 13% greater with this figure increasing steadily with increasing distillate production. From the conservation viewpoint alone these volatile gasolines would be worth a high premium value.

Second, in spite of the seeming importance of octane numbers, its high volatility has been the chief determinant in the relative market value of natural gasoline.

Third, the manufacturing costs of natural and distillate gasoline are substantially below those of much of the refinery produced gasolines. On any of these bases, natural and distillate gasclines merit the most serious consideration of the refining and automotive industries.

Reverting to the question of the future trend in volatility of motor fuel there is considerable doubt in the authors' minds as to whether the *average* motor fuel will become less volatile even with the addition of catalytic high boiling naphthas. There are a number of other major developments, either in progress or to be anticipated, all but two of which tip the volatility balance in the other direction. These several developments are as follows:

(1) The rapid growth of the distillate industry promises to add to the motor fuel supply a considerable quantity of highly volatile ingredients. In the past decade the volume of distillate production has risen from almost nil to its present stature of more than half the natural gasoline production. Distillate production arises from deep petroleum deposits and it is to be anticipated that as deeper and deeper drilling is resorted to there will be more and more distillate production.

(2) The octane number competition brought on by catalytic cracking and by automotive developments may force many refineries to make still more volatile straight-run gasolines and this will be particularly true of refineries where no modern facilities or not enough have been installed.

(3) The heavy ends of straight-run gasolines and light naphthas excluded from the motor fuel market will be submitted to reforming operations which in turn will become more severe as a result of the demand for higher and higher octane numbers. It is a well known fact that this will result in a marked increase in volatility.

(4) It is further to be anticipated that

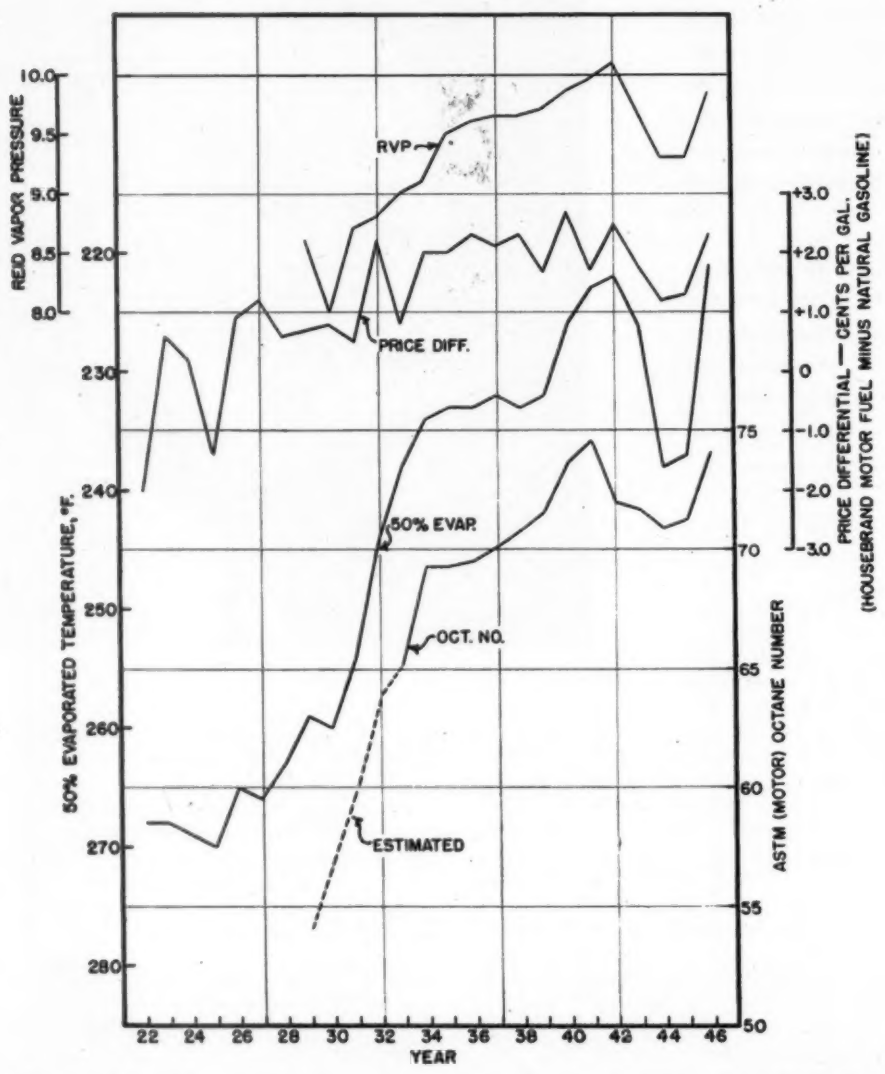

Fig. 1—Volatility and octane number of housebrand gasoline, price differential between housebrand and natural gasoline in the central states, 1922-1946

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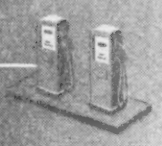

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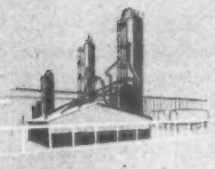

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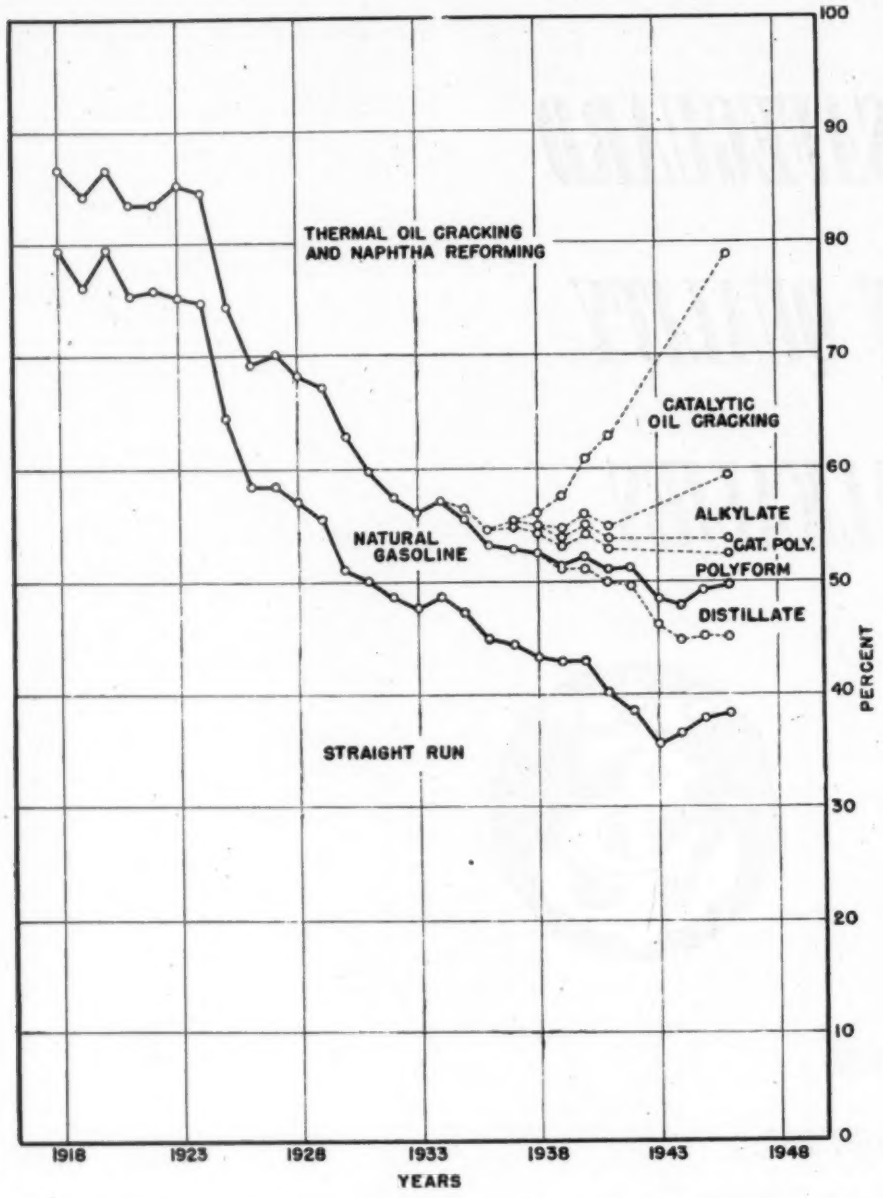

Fig. 2—Percentage composition (by manufacturing processes) of gasoline supply. 1918-1946

the severity of thermal cracking operations will have to be increased to keep pace with the octane number demand and this too will result in an increase in volatility.

(5) All of these operations, with catalytic cracking added, result in a considerable increase not only of very volatile vapor recovery gasoline but also of C_3 and C_4 hydrocarbons at refineries. Conversion of the C_3 and C_4 streams to motor fuel by catalytic polymerization and polyforming was well advanced before the war. During the war alkylation was highly developed. It is to be expected that such operations will continue their growth and all of them result in gasolines of higher than average volatility.

(6) The rapidly expanding market for aviation gasoline by virtue of its requirements for fuel of high volatility will have a tendency to decrease the volatility available for motor fuel.

(7) One other important factor which will tend toward lower volatility is the effect catalytic oil cracking operations will have on the naphtha reforming, thermal cracking, straight run undercutting and other operations at refineries equipped with catalytic cracking facilities. It is quite likely that many of these operations will be revised to produce gasolines of reduced volatility.

There are, of course, many other factors which exert or may exert an influence on the volatility of the average motor fuel, such as the demands for solvent naphthas, kerosine, light distillates, the chemical and fuel markets for light hydrocarbons, the developments in jet and gas turbine engines, the markets for fuel oil and Diesel fuel, and the growth of natural gas conversion processes such as modifications of the Fischer-Tropsch process. It is thought, however, that the seven factors specifically cited above will exert the greatest influence in the immediate future.

Fig. 2 is a graphical presentation of the past major sources of motor fuel, and illustrates the probable relative importance of the several factors mentioned above. It is to be noted that straight-run gasoline has declined rather steadily from about 80% of the supply in 1918 to about 38% in 1946. However, the proportion of the motor fuel supply made up of natural gasoline and distillate has been increasing at almost the same rate as the straight-run gasoline proportion has been decreasing. The net result is the production of virgin volatile gasolines has been about 50% of the total for the past 8 years. It is anticipated this trend will continue.

The production of "polyform," cat poly and alkylate gasolines initiated in the middle and late 30's now represents about 8% of the supply and the proportion of these volatile gasolines should increase somewhat. This leaves less than 42% of the supply to come from thermal and catalytic cracking and naphtha reforming. It is estimated that about half of this is now catalytic oil cracking and it is expected this proportion will increase at the expense of thermal cracking. This 20% is the major portion of the motor fuel supply that will become less volatile while the other elements either become more volatile or remain constant in volatility.

To be more specific on this point, it was thought it would be useful in this discussion to have an appraisal of the effect of the addition of high boiling naphthas on the volatility of motor fuel. For this purpose the motor fuel and the high boiling naphtha with volatility characteristics as shown in Fig. 3 were selected. The high boiling naphtha was blended with butane to the Reid vapor pressure of the gasoline. This blend was then mixed with the gasoline so ratios of high boiling naphtha to gasoline of 0.1, 0.2, 0.3, 0.4 and 0.5 were obtained. The volatility characteristics of all the blends are also shown in Fig. 3.

For the sake of this discussion it may be assumed that the motor fuel shown in Fig. 3 is average in volatility. It is reasonable to expect that refineries without catalytic cracking facilities will have to make their motor fuel more volatile than average and such gasolines will fall below the average motor fuel curve. The motor fuel produced by the refinery with large catalytic cracking capacity producing a very high ratio of high boiling naphthas will be toward the middle or less volatile side of the family of blend distillation curves.

When all factors are taken into account as shown by a general consideration of Figs. 2 and 3 as to the effect of the high boiling naphthas from catalytic

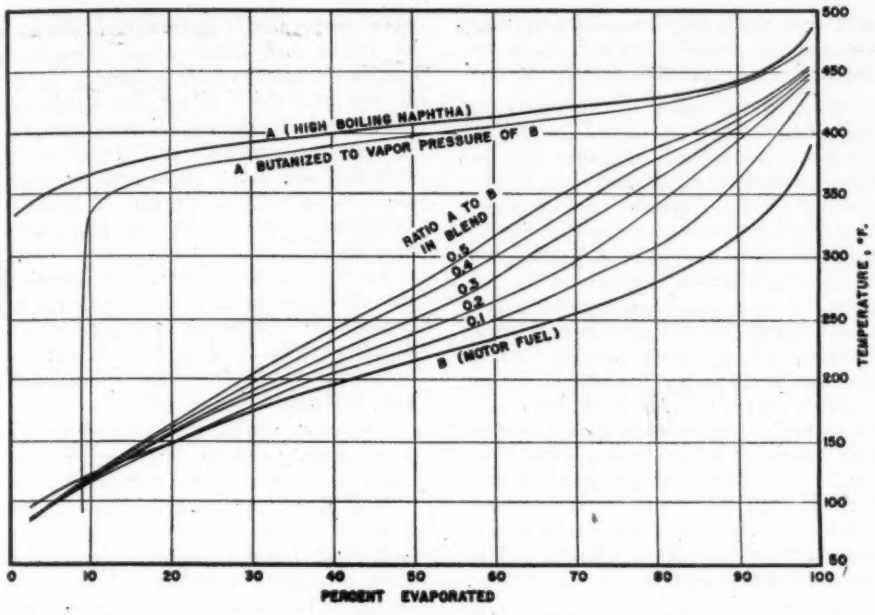

Fig. 3—Effect on ASTM distillation curves of adding high boiling naphtha to motor fuel

cracking on the volatility of the average motor fuel it is quite likely that the overall effect lies somewhere under the 0.1 ratio in Fig. 3. The net effect of all factors may even result in an increase in the volatility of the average motor fuel.

An important conclusion to be derived from a study of Fig. 2 is that one may expect much greater variations in the volatility of motor fuels than has been experienced in the past. Heretofore, it has been almost axiomatic that an increase in octane numbers was accompanied by increased volatility. Consequently there was a more or less general trend. Regardless of the manufacturer's proportionate supplies of straight-run, natural and cracked gasolines as octane numbers increased there was a corresponding increase in volatility. Until a new equilibrium is established the refinery without a supply of catalytic naphthas will be forced to increase volatility in direct opposition to the volatility trend established by the gasoline manufacturers who have catalytic naphthas.

With the advent of the large scale use of a greater variety of refining processes there is certain to be a greater variation in the volatility of motor fuels than there has been in the past. This variation has been large but rather consistent as is shown in Figs. 4, 5, and 6* which portray the deviations from the average of central states housebrand gasolines in the 10, 50, and 90% distillation temperatures for the following:

Most volatile housebrand gasolines.

Average of 20% most volatile housebrand gasolines.

Average of 20% least volatile housebrand gasolines.

Least volatile housebrand gasolines.

Average of premium gasolines.

Average of third grade gasolines.

The data shown are quarterly averages. No pronounced seasonal trend is indicated in the deviations from average.

* Figs. 4 and 6 which portray the deviations from the average in the 10 and 90% distillation temperatures respectively are omitted. Variations from the average in the 10% boiling points are considerably less than for the 50% point as shown in Fig. 5, and deviation from the average in the 90% point in general is not greatly different than the variation for the 50% point.

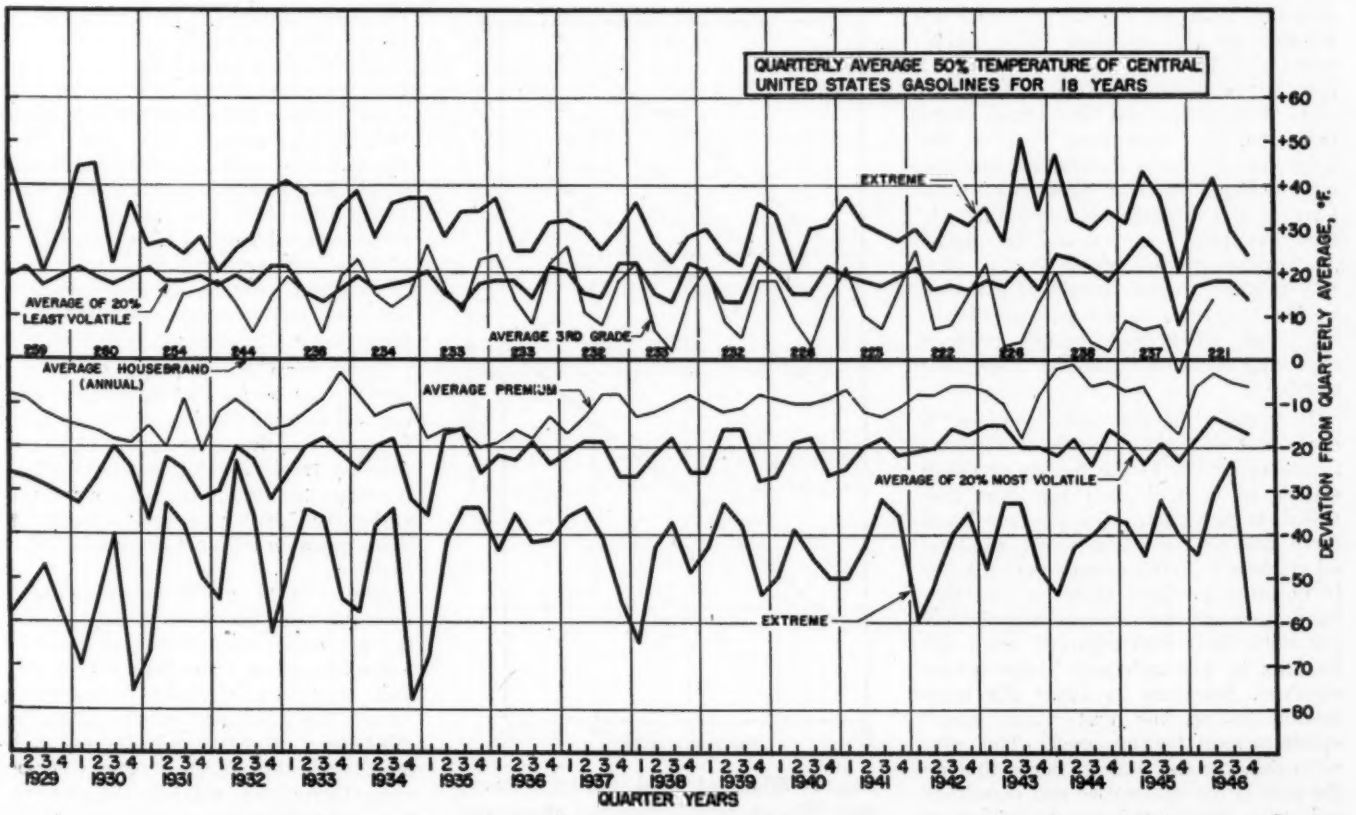

Fig. 5—Variability of 50% distillation temperature of central states motor gasolines, 1929-1946

When it is realized that on these deviations must be superimposed the variations in volatility of west, east and Gulf coast gasolines, the variations in premium and third grade gasolines, and the long term trend in volatility it will be concluded that the automotive engineer must design an engine capable of satisfactorily digesting motor fuels of a wide range in volatility. Thus the 1934 automobile during its normal 8-year life using only central states housebrand gasolines within the 80% bracket could have encountered first quarter gasolines ranging in 50% points from 185 to 254° F. In its travels east, west, and south using premium and third grade gasolines and occasionally encountering extremes in volatility this 1934 automobile would have experienced much greater variations in mid-point volatility.

The 50% distillation temperature is of particular importance in the settings of automatic chokes. No general data are available on the range in volatility that can be accommodated by a single setting of automatic chokes. Judging from a few random observations the range must be rather small. It would seem that this feature of automotive design will merit careful engineering for it is anticipated that the already considerable variation shown in Figs. 4, 5, and 6 will become even greater.

One other important general observation may be derived from Fig. 2 and this is in regard to octane numbers and particularly in regard to the current emphasis, both technical and economic, that is being placed on Research octane numbers and the great importance currently attributed to the so-called "high jump" gasolines. The data presented in Fig. 2 can be subdivided into processes that yield "high jump" and "low jump" motor fuels. On the "high jump" side of the ledger can be placed thermal and catalytic oil cracking, naphtha reforming, polyforming and catalytic polymerization. On the "low jump" side would be placed straight-run, natural, distillate and alkylate gasolines, which incidentally except for the last, have the lowest manufacturing costs. The "low jump" gasolines constitute about 53% of the motor fuel supply.

Here again the automotive engineer is confronted with the certainty of a greater future variability in the quality of filling station motor fuel than has ever prevailed in the past. On the one hand there will be the refinery with catalytic oil cracking facilities manufacturing highly sensitive gasolines while on the other hand there will be refineries manufacturing motor fuels with relatively small differences in Research and Motor octane numbers. Somehow or other the large proportions of low cost, "low jump" gasolines must be consumed. This situation calls for the utmost cooperation on the part of the automotive and petroleum industries. Either industry by virtue of the investments it may make during the next few years may unnecessarily bring about major obsolescence with huge new investment requirements for the other.

It was stated earlier in this paper that the octane number of natural gasoline has remained unchanged and that this has been particularly significant since the beginning of the "octane number race." There are many reasons for this but the chief reason is that natural gasoline has a very high octane number in its own right. This is demonstrated by Fig. 7 which shows the clear and leaded octane numbers for a rather average natural gasoline as its vapor pressure is varied. A rough rule of thumb would be to add 68 to the vapor pressure to get the octane number when leaded with 2 cc. TEL. The 26-lb. natural gasoline with 2 cc. TEL in Fig. 7 has about 92 octane number. At 30-lb. vapor pressure the octane number with 2 cc. TEL would be about 94 octane number.

This ready availability of a very high octane number gasoline, constituting about 10% of the total motor fuel supply, should strike a responsive chord among those automotive engineers who are contemplating the possibilities of much higher compression ratios. It should also strike a responsive chord among refinery engineers because the vapor recovery gasoline produced at refineries could double the potential supply of high vapor pressure, high octane number gasoline. Thus on the one hand we see a large potential supply of a very high quality motor fuel while on the other hand

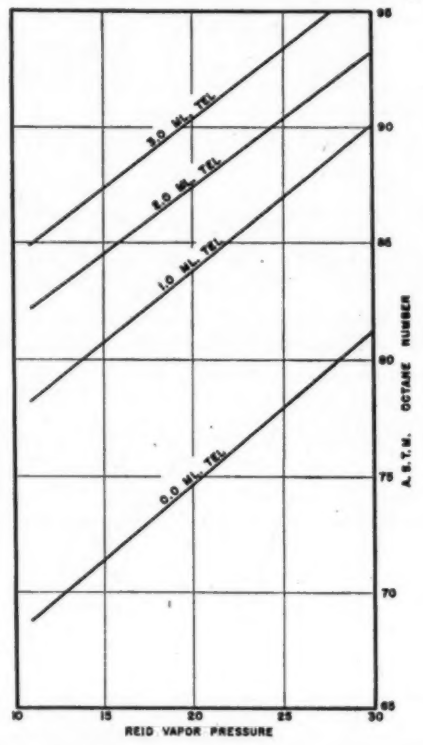

Fig. 7—Effect of Reid vapor pressure and TEL on octane number of natural gasoline

there is specialized equipment in the form of trucks and buses where application might be economically achieved. In the background there is all the experience that has been gained in the producing, storing, transporting and handling of liquefied petroleum gases and especially the considerable direct use of liquefied petroleum gases in internal combustion engines.

To the natural gasoline manufacturer the development of a direct use for his product would be of paramount economic significance since it could alleviate to a large extent the place value handicap heretofore mentioned.

The most significant aspect of such a development would be of a much broader scope than could be realized by the natural gasoline industry alone in that it would substantially increase the motor fuel yield from a barrel of crude oil. Thus if enough trucks and buses were equipped to use 10% of the motor fuel consumption in the form of 30 lb. vapor pressure gasoline it would have the effect of raising the average vapor pressure of motor fuel from its present level of about 10 lbs. to 12 lbs. If such consumption amounted to 20% of the total the average vapor pressure of motor fuel could be raised to about 14 lbs.

It is interesting to speculate on the quantities involved in such a development using 1946 data. At the 10 and 20% consumption levels the volume of C_4 hydrocarbons thus diverted directly to motor fuel would be 36,700,000 and 73,400,000 bbls. per year in excess of that used in the 1946 motor fuel. These represent about 4.8 and 9.5% of the total motor fuel supply. On the basis of motor fuel production only it would have been necessary to run to stills 4,487,000 or 4,232,000 instead of the 4,743,000 bbls. per day actually run. For the year the reduction in crude oil requirements would have amounted to 93.147,000 and 186,294,000 bbls. for the 10 and 20% consumption levels. The net conclusions of these calculations is that every barrel of additional butane so used would reduce the refinery crude oil requirements for motor fuel production by 2.5 bbls.

These considerations suggest a possible joint enterprise for the automotive, refining and natural gasoline industries in the form of the development of high compression truck and bus engines and the necessary transportation, storage and marketing facilities for the utilization of high vapor pressure high octane number motor fuels.

The natural gasoline and distillate manufacturers are greatly interested in the many processes that have been advanced in recent years for the conversion and treatment of light hydrocarbons. Among these processes may be mentioned alkylation, catalytic and thermal polymerization, isomerization, superfractionation, thermal and catalytic dehydrogenation, desulfurization, polyforming and catalytic reforming. An important factor

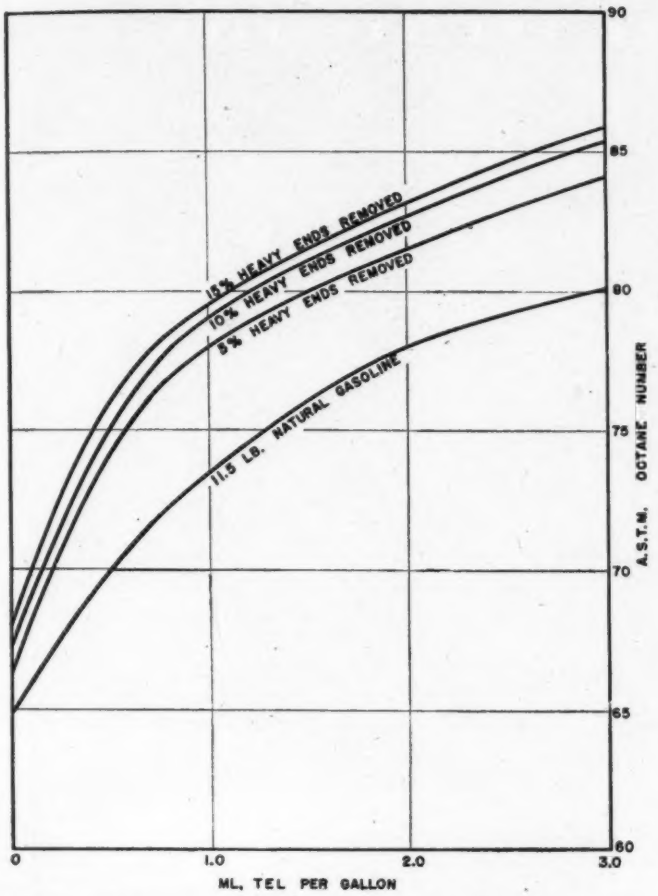

Fig. 8—Effect on octane number of end point undercutting of a sweetened 11.5-lb. natural gasoline

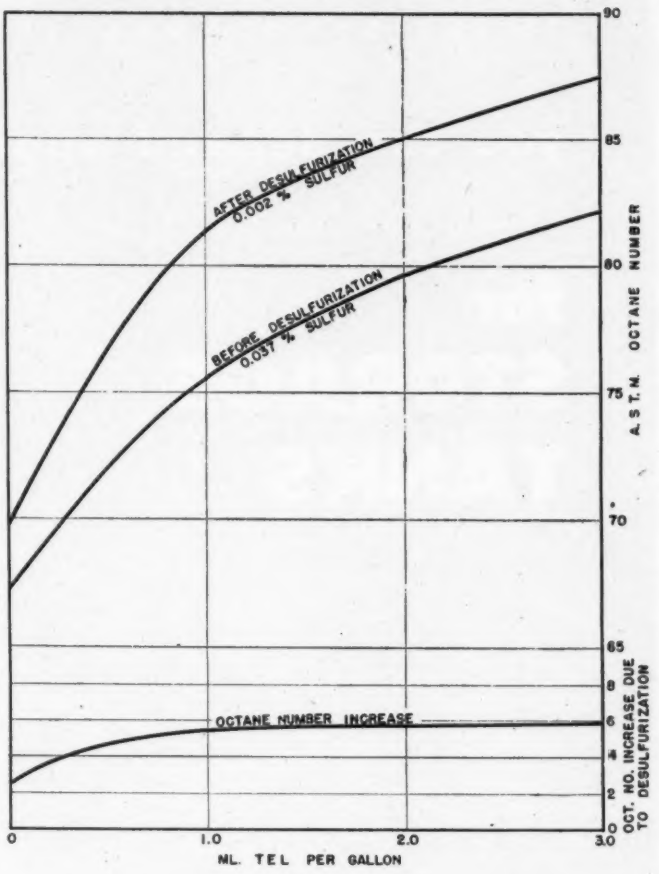

Fig. 9—Effect of desulfurization on octane number of a 12-lb. natural gasoline

in his interest is the knowledge that the products of his plant have a market value about equal to the market value of crude oil. If crude oil can be transported hundreds of miles and then subjected to these complex process steps why should they not be economically applicable to his deluxe crude oil in the form of natural gasoline and liquefied petroleum gases. The answer invariably is that the small amount of feed stock available to the average size natural gasoline plant cannot under any circumstances pay out the large investments which are disproportionately high primarily because of the small size of the operation.

However, the size of the operation can be multiplied considerably if attention is given to the full significance of the gas conversion processes. In effect these new processes say that propane and butane certainly, and ethane, less certainly, can be converted in high yields to motor fuel at low enough costs to be worthy of consideration. A study of natural gas composition data indicates that over and above the natural gasoline extracted the natural gas contains ethane, propane and excess butanes amounting to as much as 5 times the gallonage of 26/70 natural gasoline. Thus in reality a 10,000 gal. per day natural gasoline plant may have potentially a feed stock supply amounting to as much as 1000 b/d. Often there are several such plants in fairly close proximity. For natural gasoline plants of 10,000-gal. per day capacity could muster about 4000 b/d of ethane and heavier charge stock and this would be in the range where economical size gas conversion plants might become possible.

The basic concept in this suggestion is that natural gas processing plants would function as demethanizers of an ethane and heavier "crude oil" which would be charged to a light ends refinery. Much needs to be developed in regard to the demethanization step and also in regard to the processes for converting ethane, propane and butane to liquid products. Nevertheless, the possibilities exist. It is reasonably certain that some preliminary steps along these lines will be taken in the not too distant future. If economically successful one may look forward to the day when recycling of distillate and pressure maintenance pool gas will be repeated with the second recycle for the recovery of ethane, propane and butane instead of for the recovery of distillate, natural gasoline and liquefied petroleum gases.

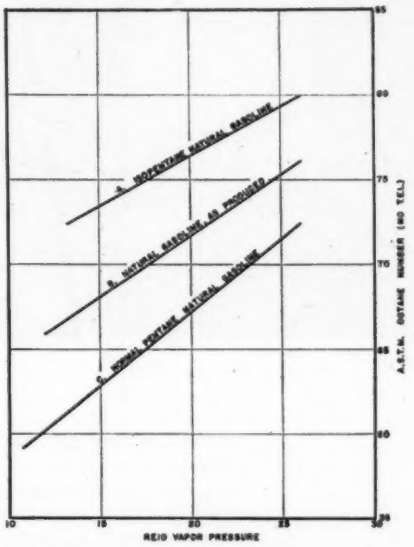
A. NORMAL PENTANE NATURAL GASOLINE
B. NATURAL GASOLINE AS PRODUCED
C. NORMAL PENTANE NATURAL GASOLINE
A.S.T.M. OCTANE NUMBER (NO TEL)
REID VAPOR PRESSURE

Fig. 10—Octane number effects of superfractionation and isomerization of pentane fraction of natural gasoline

A Further Operation

The size of the light end refinery suggested above can be multiplied further if to the ethane, propane, butane, and natural gasoline is added all or part of the straight-run gasoline in the crude oil associated with the natural gas production.

Operations at cycling plants are illustrative of the boost that straight-run gasoline might give to a light ends refinery. One such example is the South Coles Levee cycling plant in California. The production and recovery data shown in

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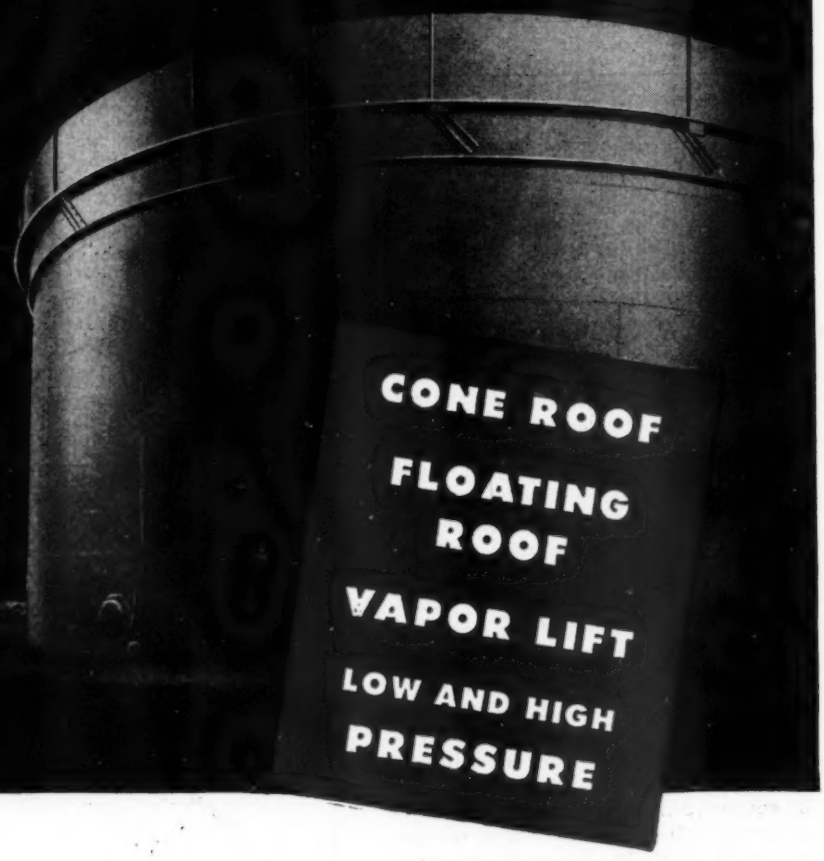

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the following tabulation are from a recent brochure on this installation.

Product	Prod. b/d	% Recov.	Total Potential b/d
50° API Debutanized Condensate	4650	..	4650
Natural Gasoline	715	..	715
Normal Butane	660	98	673
Isobutane	440	88	500
Propane	600	30	2000
Total	7065	..	8535

In this case the total potential feed stock for a light ends refinery is 12 times the volume of natural gasoline. It may be estimated that the inclusion of ethane would raise this to 16 times the natural gasoline.

Based on averages pertaining to natural gasoline situations it seems likely that oil pools or combinations of oil pools producing about 16,000 b/d might offer the potentiality of as much as 10,000 b/d of ethane through straight-run gasoline as feed stock for the light ends refinery. This potential feed stock might have the following approximate composition:

	b/d
Straight run gasoline	4000
26/70 Natural gasoline	1000
Excess butanes	400
Propane	1100
Ethane	3500
Total	10,000

In this hypothetical case the potential feed stock for the all-inclusive light ends refinery is 10 times the natural gasoline production.

It is not beyond the realm of possibility that hydrogenation of the topped crude oil using the hydrogen resulting from light gas conversion could be economically possible to improve the "pumpability" of the crude oil for transportation purposes and to improve its "refinability".

Admittedly such developments as these are very much in the future. They are, however, no stranger today than today's practices were 20 years ago.

To be more immediately practical the time may have arrived when natural gasoline manufacturers will be compelled to improve the antiknock characteristics of natural gasoline. There are some expedients that seem worthy of consideration at this time and for natural gasoline plants as they exist today. The following are some of these expedients:

(1) The elimination of a few per cent of the heavy ends of natural gasoline has a disproportionate effect on the octane number and particularly the leaded octane number. The few per cent of heavy ends of natural gasoline are made up mostly of absorption oil, lubricating oil and crude oil and are very high in sulfur. The results of such an operation are shown in Fig. 8. Data obtained subsequent to those shown in Fig. 8 have demonstrated that some of the octane number improvement illustrated was attributable to the desulfurization achieved.

(2) The desulfurization of natural and distillate gasolines offers a low cost method of improving the leaded octane numbers of these materials. Fig. 9 is illustrative of the results to be obtained by this procedure.

(3) The extension of superfractionation at least to the pentanes fraction provides an opportunity to separate the product into a premium "iso-natural" and a very useful normal natural gasoline. (Fig. 10)

(4) The isomerization of normal pentane, which amounts to 10 to 20% of the 26/70 gasoline, gives a 27 octane number increase to this portion of the product. Thus a cost of several cents a gallon of normal pentane would represent a fraction of a cent per gallon of 26/70 and would bring about an increase of 2 or more octane numbers in the overall product. The entire product would fall on the top curve of Fig. 10.

(5) At distillate plants of sufficient size it seems probable that some variation of "polyforming" or of catalytic reforming will soon become necessary and desirable.

(6) Natural gasoline could be separated very justifiably into two products with butane-pentane or butane-pentane-hexane mixtures going to refiners for refinery blending and the heavier ends going to local motor fuel markets, to local refineries, or to crude oil lines.

Discussions of motor fuel quality are very apt to give the impression that the octane number of automotive gasoline is the only property that needs consideration. For anyone who becomes too strongly wedded to this data there is a very simple blind fold test. Let him add 25% of low vapor pressure natural gasoline to his favorite gasoline and compare the performances of this blend with the performance of the favorite gasoline on practically any day between Nov. 1st and May 1st. The experimenter, no matter how amateur, would be able to notice perceptible differences in starting, in acceleration during warm-up and in acceleration after warm-up. In stop-and-go driving he would encounter a considerable improvement in consumption with almost as good economy in steady driving. Indeed the experimenter would discover how big the seconds and fractions of seconds are that are used in such expressions as "time to accelerate from 15 to 30 miles per hour."

Yes, volatility is the forgotten property of motor fuel. Nevertheless it is a basic factor in the design and performance of automotive engines. The fact that octane numbers have increased in recent years is often considered to be the only reason automotive engineers have been able to improve automotive performance. However, besides other factors, the concurrent increase in the volatility of motor fuel has also been a major contributor to this improvement in automotive performance. And, as long as the blind fold test will work just that long will the natural gasoline manufacturer be able to watch the octane number race with the detachment that has prevailed in the past.

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Photo Cells Used in Controller For Catalyst Regeneration Unit

In addition to the specific gravity controller described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued includes:

- **Improved slip gage for accurate volume measurements**
- **Fin-type heat exchanger with baffles for better transfer**
- **Device provides continuous control of specific gravity**
- **Drum truck that simplifies up-ending operations**

Two PHOTO-ELECTRIC cells, picking up the variations in the amount of light passing through a pyrogallol indicator solution, are the essential parts of a continuous, automatic, oxygen-controlling device.

Said to be particularly adaptable for use on catalytic units for efficient control of the regeneration step, the operation of the instrument is shown in Fig. 1.

Pyrogallol solution passes slowly through tube 2, dripping into contact chamber 4, and on into lower vessel 12. Regeneration gases from the reactor also enter contact chamber 4 via tube 10. Any oxygen present reacts with the indicator, the gas then passing on through and out via tube 14.

Light rays from source 1 are made to pass through tube 2 and point 3 on to two photo cells 5 and 6. During normal regeneration, no oxygen comes through in the gas, consequently the amount of light received by both cells is equal. As soon as oxygen does come through, its presence is detected by the indicator, darkening the solution at point 3, and photo cell 6 receives less light than does 5.

The unbalance thus created in the relay circuit effects an energy impulse which is used to shut off the air stream to the regenerator or whatever purpose is desired.

U. S. 2,417,877, issued March 25, 1947, to Elton R. Lewis, assignor to Standard Oil Development Co.

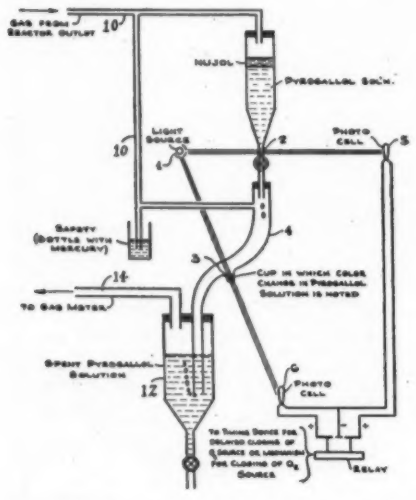

Fig. 1—Diagrammatic sketch of automatic oxygen detector and controller (U. S. 2,417,877)

Improved Slip Gage Prevents Inaccurate Tank Car Readings

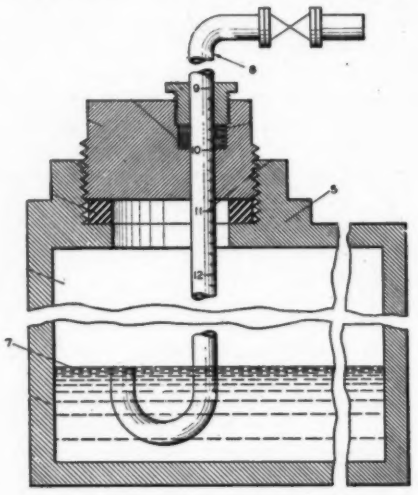

Fig. 2—One form of the improved slip gage for measuring liquid level in containers of LPG (U. S. 2,419,257)

INACCURATE LIQUID level readings in the measurement of tank or tank car volumes of liquefied petroleum gas are said to be eliminated in a new type of slip gage which prevents premature entrainment of liquid.

One modification of the invention is shown in Fig. 2. A sketch of the conventional slip gage is shown in Fig. 3. Liquid container is indicated generally at 5, liquid level to be measured at 7. The typical slip gage 8 has been improved by providing a U-tube bend at the bottom end.

A clear-cut change of liquid to vapor is indicated with this type of gage because no premature entrainment of liquid occurs. Sketch of conventional gage in Fig. 3 illustrates how much entrainment may occur, as much as ½ inch above the true level of the liquid. In containers as large as tank cars, elimination of such inaccuracies is very economical.

U. S. 2,419,257, issued April 22, 1947, to Edmond W. Evans, assignor to Phillips Petroleum Co.

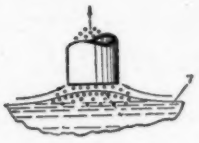

Fig. 3—Premature entrainment of liquid and subsequent false readings occur with conventional slip gages

Baffles in Fin-Type Exchanger Effect Better Heat Transfer

INCORPORATION OF baffles inside the shell of a fin-type U-tube, shell and tube, heat exchanger increases the efficiency of heat transfer by creating a longer, zig-zag path of flow for the fluid passing through the shell.

Several modifications of the invention have to do in the main with the method of securing the baffles in place. The entire unit is so arranged that cleaning or repairing is simplified. The baffles and tubes form an integral assembly with the main end cover plate that can be easily removed in one piece.

U. S. 2,418,405, issued April 1, 1947, to Addison Y. Gunter and George B. Farkas, assignors to American Locomotive Co.

Instrument Provides Continuous Control of Specific Gravity

SPECIFIC GRAVITY of a liquid can be continuously measured, recorded, and controlled by means of a new device which is said to respond accurately to very small changes in the density of the liquid.

The complete control system is shown in Fig. 4. The liquid whose specific gravity is to be measured and controlled passes constantly through sampling tank 1 by means of inlet 2 and outlet 3, which maintains a constant level in the tank.

Guide bars 4 float 5 as it raises or lowers due to changes in the density of the liquid. The float 5 is made preferably of some material which will not react with the liquid. Weights 6 inside the float hold it submerged to the proper depth. Container 7, also in the float, is filled to a given depth with mercury 8.

Extending into the mercury is a branch 9 of an air supply pipe, another

The dimension that "specs" don't cover

Your specifications may be as complete and perfect as it is humanly possible to make them.

But the one most important dimension of all can't be written into specifications—and that's the perfection exercised by the men who do the work.

All modern shops have access to good measuring devices. All shops have inspection systems. But results can vary greatly according to the ability of the men who use the instruments and do the inspecting.

One of the principal reasons for Kellogg's high reputation in the fabricated products field is the stability of its organization and the experience of its personnel. Among employees the average length of service is 5 years; layout men average 10 years; inspectors 13 years; the senior pipe bender is a veteran of 39 years experience.

It's the extra quality that these men put into a job that guarantees more than specifications call for—when you turn those "specs" over to Kellogg.

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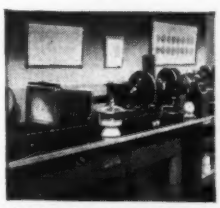

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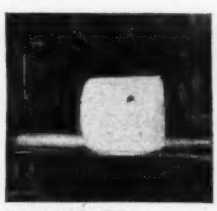

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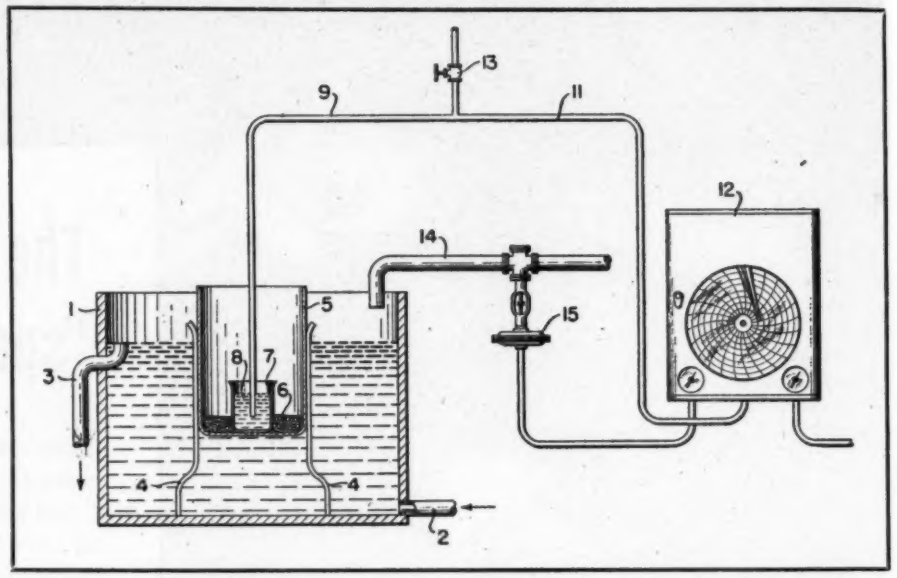


Fig. 4—Continuous control of a liquid's specific gravity is provided in this device (U. S. 2,418,592). Liquid passes through sample tank 1, controlling diluent is added by means of pipe 14

branch 11 of which extends to the responsive element of a conventional pressure measuring and controlling instrument 12.

In operation, air flow through lines 9 and 11 is regulated by valve 13 so that a slow but continuous bubbling of air occurs through the mercury. The resistance offered to the air as it bubbles through the mercury creates a back pressure responded to by the instrument 12. The pressure varies with the depth of the mercury through which the air passes. The depth is affected by the height of float 5, which in turn is affected by the density of the liquid.

In order to vary the specific gravity of the liquid, some diluting agent may be introduced through line 14 in an amount controlled by valve 15, also connected to instrument 12.

The use of mercury for transmitting density differences to back pressure differences in the air line, allows for greater magnification of such density differences and consequent accuracy of control.

U. S. 2,418,592, issued April 8, 1947, to John F. Maienshein, assignor to The Brown Instrument Co.

Drum Truck's Two-Way Rockers Simplify Up-Ending Operation

INCORPORATING parallel two-way rockers in a novel design for a drum-handling device is said to reduce man power in up-ending and general handling of heavy, filled drums.

As shown in Fig. 5, the truck consists essentially of handle 14, cradle 10, prongs 20, rollers 26, and catches 28, which hold the drum in place on the cradle.

Rockers 17, running at right angles to the perpendicular axis of the drum, permit it to be rolled into a position for easy drawing of samples. Rockers 22, running at right angles to rockers 17, provide for up-ending and placing the drum in storage.

A cross-bar 15, at the outer end of handle 14, enables a single workman to manipulate even heavy drums, it is said.

U. S. 2,418,503, issued April 8, 1947, to Wilson R. Fox, Wyandotte, Michigan.

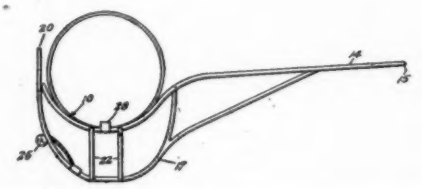
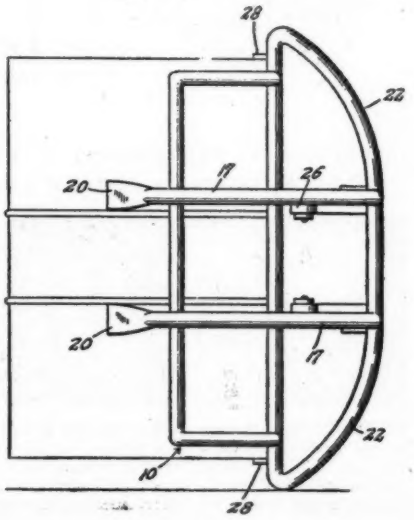


Fig. 5—Above, side view of drum truck with two-way rockers (U. S. 2,418,503). Below, end view of same truck

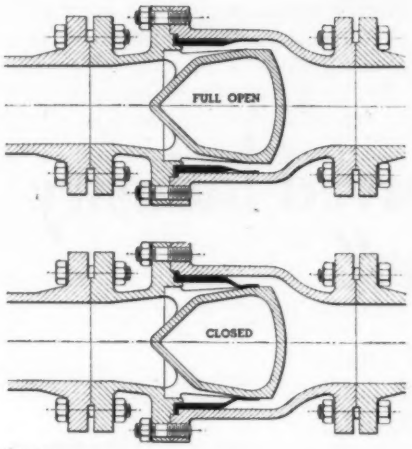


What's New!

Edited by
WILLIAM C. UHL
Equipment Editor

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

1—Check Valve



Operating on low pressure differential, the new "Chexflo" valve has no metallic operating parts. Operating member is a flexible, synthetic rubber tube with a tapered lip, expanding freely to full unrestricted flow and fitting tightly over the valve core in the closed position. The degree to which it opens or closes is in direct ratio to the volume of flow. As it reaches shut-off position, flow velocity increases to flush the seating surface of small particles. Recommended for handling air, gas, water, and refined petroleum products up to 180°F. Available in sizes from ½ to 12 in. Grove Regulator Co.

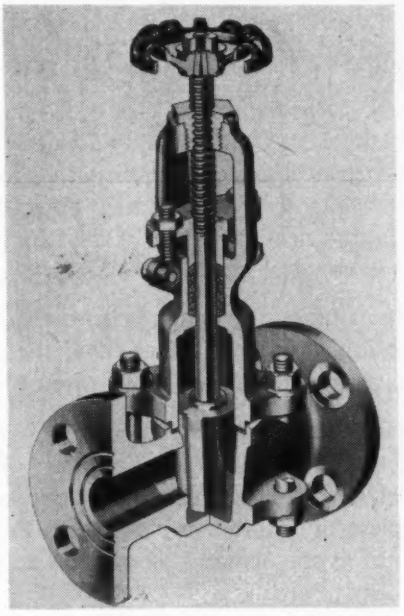
2—Steam Hose

Using spun glass yarn with rubber to gain maximum heat resistance, a new type steam hose is said to be particularly adaptable to fighting refinery and oil industry fires with live steam. It can carry 200 lbs. of saturated steam at 388° F. for more than 300 hrs. under continuous flexing, according to tests. Goodyear Tire & Rubber Co.

For More Information

USE one of the attached business reply cards, which requires no postage, to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail.

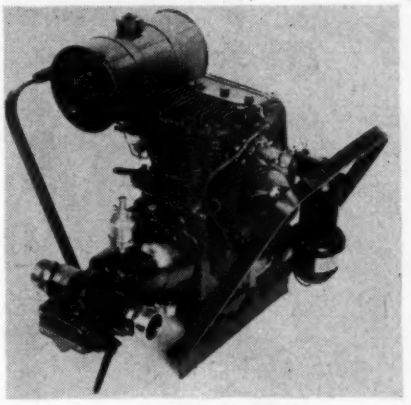
3—Plug Gate Valve



Combining the advantages of the two important basic types of valves, a new line of corrosion-resistant plug gate valves provides straight-through flow in the wide-open position as do conventional gate valves, yet is suitable for throttling service as conventional globe valves. Of outside-screw-and-yoke design, the new valves have bolted bonnet joints and are available with either screwed or flanged ends in sizes from ½ to 2 in. They are furnished in either 18-8 Stainless steel or Monel metal or may be made from other alloys to fit particular specific corrosive conditions. Tests have shown flow rates are equal to wedge gate valves. Crane Co.

4—Portable Pump

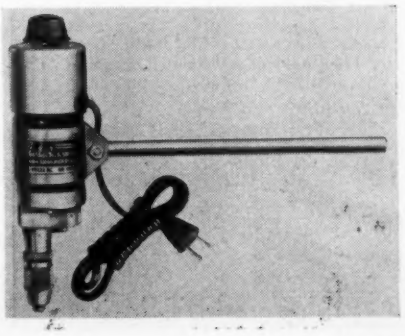
The new "MP" Duraflex 6600, a portable, high-pressure pump carrying rubber impellers, delivers over 40 gpm at 120 psi and has a suction lift of



over 30 ft. An automatic by-pass valve relieves pressures in excess of 150 psi, makes it possible to start pumping against a head of water. The rubber rotors will pump solids and abrasives with low wear. Self-contained power source is a single-cylinder, four-cycle, air-cooled, gasoline engine rated at 5 hp., with its own crankcase oil supply, and connected directly to the pump shaft through a splined sleeve. A pulley-equipped model is also available for external belt-driven power application. Marine Products Co.

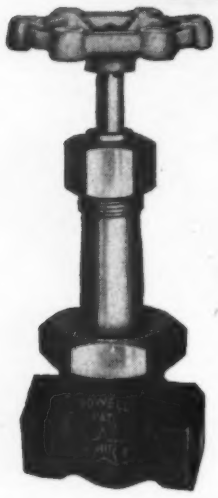
5—Laboratory Stirrer

"Power-Stir" is a light-weight stirrer using a 15 to 1 gear reduction to develop high torque with variable speed. Motor is resistance controlled; plastic knob for rheostat on top of housing. Without load, speed range is 450 to 1200 rpm, overall height without paddle, 9½ in.; weight 3½ lbs.; mounting rod, 9 x ½ in. Operates on 115 volts, 60 cycle AC or 115 volts DC. Eberbach & Son Co.



Since 1846

Powell Valves have served Industry
...and served it well.



Small size 200-pound Bronze Gate Valve for steam, water, oil or gas. Has inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze disc.

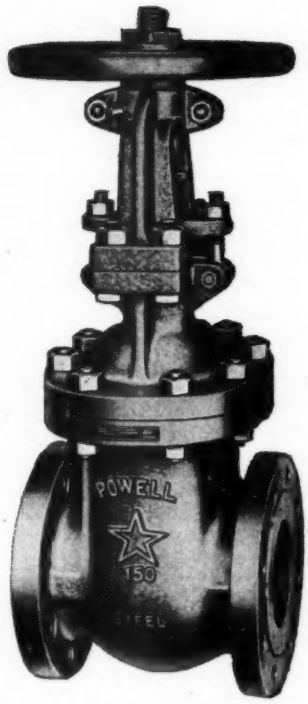
'Way back in the "horse and buggy days", the first regrinding globe valve was produced and patented by Powell. And ever since then Powell has been a leader in the field of industrial flow control equipment.

As amazing as the changes in methods of transportation have been since 1846, the progress of industry has been well nigh incredible.

Through more than a century of keeping pace with the flow control requirements of each new industrial development, Powell has built such a complete line that today there's a Powell Valve to meet every demand of modern industry.

The Line now includes Bronze and Iron Valves of every required type, design and size; Cast Steel Valves of every type, in pressure classes from 150 to 2500 pounds, inclusive. And, to meet the demands of the Chemical and Process Industries for corrosion resistant valves, Powell makes a complete line, including many special designs, in the widest range of pure metals and alloys ever used in making valves.

Large Iron Body Bronze Mounted Globe Valve for 125 pounds W.S.P. Made in sizes 2" to 16", inclusive. Has outside screw rising stem, bolted flanged yoke and regrindable, renewable bronze seat and disc. Also available in All Iron.



Class 150-pound Cast Steel Gate Valve with bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

The Wm. Powell Company, Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

What's New!

6—Emergency Escape Mask

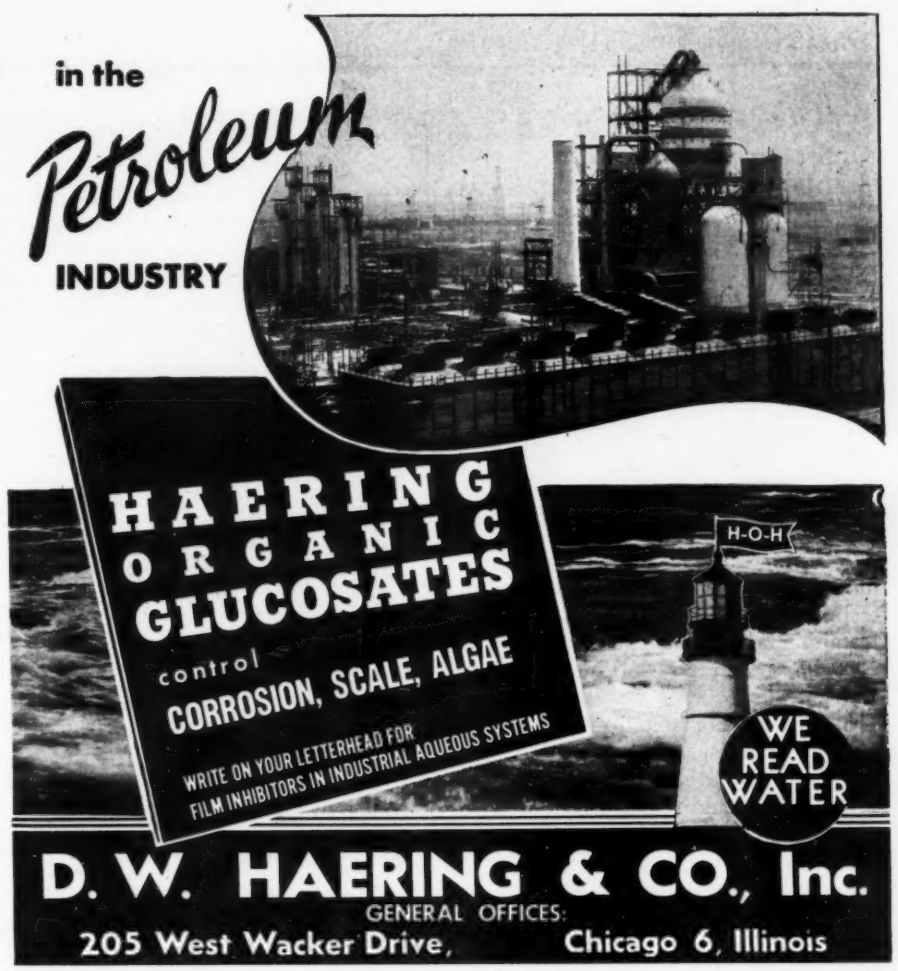
The new Front-Type Demand Mask has a service life of about eight to ten minutes. It is recommended particularly as an escape apparatus for leaving suddenly developed toxic atmospheres, or for short duration jobs such as shutting off a valve in toxic atmospheres. Weighing about 13½ lbs., the apparatus has an 11 cu. ft. capacity high-pressure cylinder, furnished optionally with either oxygen or certified pure air at an initial charging pressure of 1800 psi. Conventional demand regulator and the MSA All-Vision facepiece deliver oxygen or air in the flow exactly as needed by the wearer. The cylinder is held in place on the chest by an adjustable web harness. Mine Safety Appliance Co.

7—First Aid Cards

A continuous series of 5 x 8 in. ready reference cards for use in plant or dispensary give, in brief and concise form the details and effects of various chemical compounds on human beings whether inhaled, swallowed or contacted by skin or eyes, together with simple first aid procedures. For a number of materials the systematic effects are also listed. Recommendations are made for proper protective equipment. Compounds and materials covered to date include gasoline, sulfuric acid, phenol, aniline, nitrobenzene, ammonia, toluene, benzene, methanol, caustic soda, sulfur dioxide, phosphoric acid, non-toxic dust, and several others. Benson & Associates, Inc.

8—Liquid Level Control

The Photoswitch Level Control, Type 10CB1X, can be utilized in tanks and vessels where the liquid to be controlled will conduct a minute current at the low voltage required for the operation of the relay. Two stainless steel probe rods project into the tank, one reaching the low point and the other the high point of levels desired. It operates on 115 or 230 volts, 25/30 cycles A. C. Output is 5 amps. at 115 volts, and 1 amp. at 22 volts. A selection of four terminals on the terminal panel enables the probe circuit to be matched to the electrical conductivity of the liquid in question. It can be supplied in an explosion-proof housing or in a pressed steel, dust-tight enclosure. Photoswitch, Inc.



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METASAP STEARATE BASES
These photographs show grease-base reactions to extreme heat. In Lime Bases, evaporation of moisture under heat causes separation of soap from oil (Photograph A). Exposed to similarly high temperatures, clear-type, anhydrous Metasap Stearate Base Greases maintain their oil-base balance (Photograph B) because they have no moisture to evaporate. Metasap also gives your lubricants the advantage of less base, more mineral oil — the true lubricating ingredient, and provides any desired degree of body from stiff, short-feathered greases to thin fluid lubricants. Write today.
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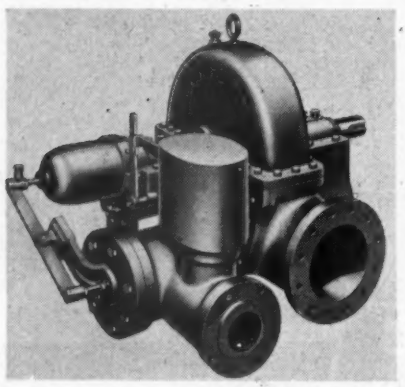
Stearates
of Aluminum · Calcium · Lead · Zinc

9—Turbines

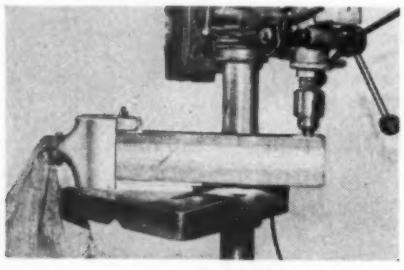


The new YR line of mechanical drive turbines is said to provide greater general flexibility and include the regular features of the Y line. Capacity up to 2000 hp, back pressure up to 250 psig, and operating speeds up to 6000 rpm. The turbines are suitable for outdoor installations through sealing the bearings and enclosing the governing parts. Parts are simplified and standardized so they can be used on two or more frames. Elliott Co.

10—Portable Welder

The P&H Model WN-200 Welder is available both as a stationary or a trailer unit. N.E.M.A. rating is 200 amps. Service range is 30 to 260 amps. Generator rating is 30 volts at 2900 rpm. Power is supplied by a heavy-duty, 4 cyl. air-cooled engine of 26.5 hp. Skid model includes large lifting eye for crane lifting. Trailer model uses running gear of standard track width, and has standard size pneumatic tires. It can be towed at normal highway speeds without side sway. Harnischfeger Corp.

11—Sanding Machine

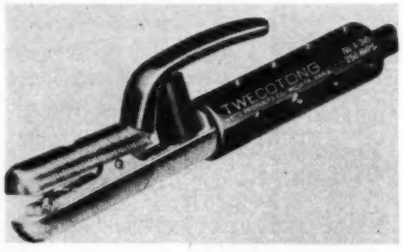


Weighing less than 5 lbs., a new belt sanding device can be attached to a drill press quickly and is said to be economical for shops where sanding operations are not extensive enough to require a full size machine. It consists of an aluminum base bolted to the drill press table, a driven pulley, and a driver pulley mounted on a ½-in. shaft to fit into the drill chuck. Moving the table adjusts the device to handle belts from 26 to 36 in. long. Taking belts from ½ to 3 in. wide, the sander is 5 in. high by 10½ in. long by 3¼ in. wide, and comes assembled ready for use with any drill press, or may be adapted for other power tools. OK Specialty Co.

12—Feed-Water Controller

Magnetic action is employed for controlling feed-water for boilers in the Micro-Netic electric controller. Weighing 7½ lbs., the instrument can be attached to a boiler to occupy a space of 3½ in. diameter by 7½ in. long for its housing, with a switch box 2 x 4 x6½ in. The monel metal ball float, capable of resisting a pressure of 400 psi, carries a steel ring which attracts the magnets when it moves into their fields. J. A. Campbell Co.

13—Electrode Holder



Built to fill the requirements of the average shop or maintenance welder using 200 amp. equipment, the A-316 Twecotong electrode holder uses molded, laminated, glass-cloth-Bakelite for tip and body insulation and Neoprene for the spring. Cable connection is a simple clamp, plus a socket for soldering if desired. Capacity is 1/16 through 3/16-in. electrodes; weight, 18 oz.; length, 9 in.; palm span, 2¾ in. The wide-opening rod grip exerts a pressure of 95 lbs. in the closed position. Tweco Products Co.

Trade Literature

14—Nitrosyl Chloride

Nitrosyl Chloride, Product Development Booklet NC-1, presenting chemical and physical properties of this chemical, and including information on handling, laboratory preparation, safety measures, and industrial applications. Applications include use as a catalyst for polymerization and in chlorination of hydrocarbons. Solvay Process Co.

15—Valve Chart

Valve Cross-Reference Chart, a new 20-page booklet contains a complete listing of OIC valve numbers in order, with their description. Ohio Injector Co.

16—Storage Tanks

The Choosing and Using of Tanks, a 78-page booklet telling how to purchase, erect, maintain, and repair storage tanks for petroleum products and raw materials. Instructions accompanied by numerous photographs and drawings. Black, Sivalls & Bryson, Inc.

17—Control Instruments

Industrial Control Devices, Catalog No. 8302, a 56-page bulletin providing schematic diagrams, dimensional drawings, specifications and range charts on electric and pneumatic controls and motorized valves. Brown Instrument Co.

18—Fractionating Tray

Koch Kaskade Fractionating Tray, Bulletin No. 101, describes and explains the principle of the new design for a fractionating tray, comparing it to the conventional type of bubble cap tray. Included are design details, and operating data in chart form. The Koch Engineering Co., Inc.

19—Water Conditioning

Carbite Carbonaceous Zeolite Softeners, Publication 4021, a revised edition in 16 pages of a previous bulletin containing flow diagrams of seven typical installations of equipment for softening boiler feed and industrial process waters. Curves, tables, and the various chemical reactions involved complete the technical data. Cochrane Corp.

20—Instrumentations

C. E. C. Recordings Vol. I, No. I, the first issue of a new quarterly publication of interest to users of mass spectrometers, static-dynamic measuring and recording systems, electrical computers, vacuum leak detectors, and the like. Consolidated Engineering Corp.

Wherever you go — whatever you do
You use products made better with BECKMAN pH CONTROL!

Did You Know These Beckman pH Facts?

...that Beckman pioneered modern glass electrode pH equipment, transforming the cumbersome laboratory apparatus formerly used into a compact, practical, portable instrument that paved the way for today's simplified pH measurement and control?

...that the first completely automatic glass electrode pH indicator, recorder and controller was pioneered by Beckman? Operating entirely without batteries, this instrument made automatic process control accurate, convenient, practical—and is today widely used in all parts of the world.

...that Beckman pioneered the High Temperature Glass Electrode system which, for the first time, enabled continuous pH measurements to be made at temperatures up to 212°F (100°C)? This electrode system is of tremendous value wherever hot process fluids must be controlled.

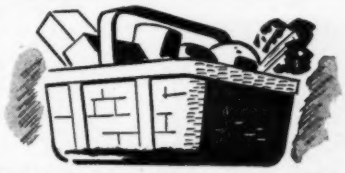
...that the High pH Glass Electrode system is also a Beckman development? This unique glass electrode unit can be used to measure high pH values even *in the presence of* sodium ions... and extends the usefulness and accuracy of glass electrode equipment to many industries where alkaline solutions in combination with sodium ions have heretofore presented difficulties.

...that the above are only a few of many developments that make Beckman pH Equipment the most advanced, the most accurate, the most adaptable in the field of pH?

The tires you ride on are made with the aid of Beckman pH Control. It was found that coagulation of the synthetic rubber is very sensitive to variations in the pH (acidity or alkalinity) of the processing solutions. Therefore, Beckman Automatic pH Equipment is used to control these processes for efficiency and economy.

The motion pictures you see are processed with the aid of Beckman pH Control. The developing laboratories of the major motion picture studios discovered that Beckman pH Equipment gives better control of the quality and uniformity of the film developing processes, insures clearer prints, less waste and better projection qualities.

The water you drink is probably Beckman pH Controlled. In more and more municipal water systems, purification of the drinking water is being regulated with the aid of Beckman pH Equipment, thus insuring a water supply that is both pure and uniform—plus important savings in treating costs.



The food you eat is another item that, today, is made better and more uniform with the aid of Beckman pH Control. It has been found that virtually all types of food processes—from baking crackers to canning meats—are performed more efficiently, more economically with the aid of Beckman pH Equipment.

Are YOU Using This Cost-Cutting Tool in Your Plant?

ONLY A FEW YEARS AGO pH control was more of a laboratory curiosity than a cost-cutting industrial tool. But today—largely through the far-reaching developments of the Beckman research staff—modern pH control has become an indispensable tool for speeding chemical processes, safeguarding quality, reducing waste and simplifying production operations throughout industry. *In fact, wherever there's water there's pH... and wherever water or water processes are used, chances are the job can be done quicker, better, at lower cost with Beckman pH Control.*

How About Your Product?

The above are but a few of the innumerable ways alert industries are cutting costs, improving product quality, reducing waste and making other vital savings with Beckman pHControl. Have you investigated the vital savings it can make in *your* operations? Our engineers will gladly study *your* pH problem and suggest ways that Beckman pH Control can save money for you. *Beckman Instruments, National Technical Laboratories, South Pasadena 23, California.*

FREE...

"What Every Executive Should Know About pH"

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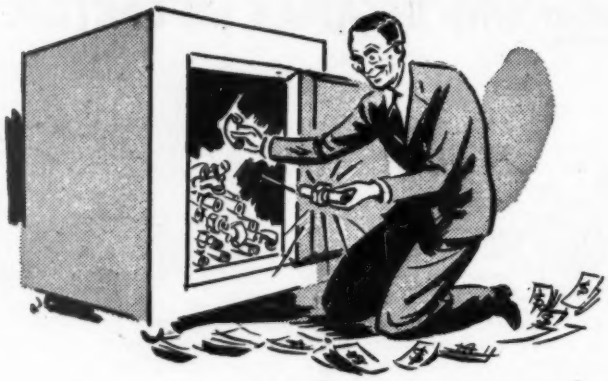
BECKMAN INSTRUMENTS CONTROL MODERN INDUSTRIES

Fittings are Scarce



save 7 per trap with SUPER-SILVERTOPS

here's how

Super-Silvertop showing one nipple and one union needed.

Conventional trap using seven fittings and two unions.

ONE WAY to conserve those "more-precious-than-gold" pipe fittings—make them go farther—is by simplifying with Super-Silvertop Steam Traps.

As you can see in the photos at the left, one nipple and one union on a Super-Silvertop takes the place of 5 nipples, 4 elbows and 2 unions on an ordinary inverted bucket trap. Super-Silvertop gives you this saving because of the built-in U-tube—designed into the trap at the factory instead of hand-made outside the trap at your plant.

Super-Silvertop design gives simplified piping in all sizes of traps, and without the weakness of cored passages or split (pierced) gaskets.

Do you want to save fittings and still get efficient trapping? Then investigate Super-Silvertop. Complete details are included in the helpful book "HOW TO CHOOSE A STEAM TRAP"—send for your free copy.

THE V. D. ANDERSON COMPANY
1974 West 96th St. • Cleveland 2, Ohio

SUPER-SILVERTOP STEAM TRAPS

A Good Book . . .

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Designing Primary Section and Accessories Of an Effective Oil-Water Separator

By W. B. HART

In Charge of Waste Disposal for Atlantic Refining Co.

Separator design is based on natural laws, and only data which have been obtained by careful and adequate survey should be used in the application of those laws.

This month the author discusses the design of the primary section of an oil-water separator, the physical data necessary for that design, and how the data is secured. He then proceeds to apply the data to a typical design problem.

Finally, he goes into details of the design and function of the various accessories required in the primary section—oil retention baffle, flow-line control baffle, oil collector pipe, flight-scraper and cleaning equipment.

THE sedimentation basin makes up the major portion of the primary section of the separator which, as will be shown later, consists of two sections, the primary and secondary sections. The primary sedimentation basin extends from the downstream side of the distribution box(169) to the most upstream point of the oil-retention baffle (Fig. 1). The basin contains the cleaning device, usually known as the "flight-scraper," and the "oil-collection pipe," also called the "oil-skimming pipe." The "bottoms" collection reservoir and flow-line control weir are also included, even though they are beyond the oil-retention baffle (which also is an accessory).

The function of the primary sedimentation basin is not principally complete oil removal. Instead, the function is to remove any condition in the waste flow which will interfere with obtaining as nearly complete oil removal as possible in the secondary basin.

Interfering conditions referred to here are largely matters of the presence of water-in-oil emulsion which will rise to the surface, or suspended matter to which oil can adhere readily and pass through the separator. *Incidentally*, the major part of the free oil in the waste also will separate in the primary sedimentation basin.

The matter of a divided separator (i.e., primary and secondary sedimentation basins) often has been questioned. To some extent such questions are justified. Obviously, if the waste carries no emulsion of any type, nor any material which could aggregate with oil so that the oil would carry through the separator (i.e., suspended matter), the functioning of the primary sedimentation basin is not needed, and the basin need not be included. Or, if some pretreatment is applied to the waste before it enters the separator, such as in a so-called presettling sump or basin, the wastes may be delivered to the separator free of interfering substances. But wastes only infrequently enter the separator in such satisfactory form.

The usual reason advanced for eliminating the primary section of the separator is to reduce costs by putting a pre-sedimentation basin ahead. It is claimed that such a basin can be constructed much more inexpensively. It can, but it will function at very low efficiency, and if it simply is a dug pit, maintenance and cleaning soon will wipe out any saving which may seem to result from construction of poor or undersized equipment.

It should be remembered that the same natural laws govern sedimentation, regardless of location. The primary basin design is based on these laws, and it provides high efficiency. It is unreasonable to assume that liberties can be taken with the laws and have high efficiency maintained.

Determining Separator Length

As said previously, the width and flow depth of the primary basin of the standard size separator have been established as 20 ft. and 8 ft., respectively. There remains the length to be established. The length is a function of the rate of rise of a small globule of oil, i.e., 0.02 cm. diameter, in relation to the average velocity of the flow through the separator, assuming that the oil must rise through the full depth of flow. As has been shown, the actual path of the oil globule is the vector of a rectangle defined by these values.

The rate of rise can be found by applying Stokes' Law:

$$V=\frac{1}{k}\cdot\frac{2g(\rho-\rho_1)r^2}{9\eta}$$

in which $k=\dfrac{\frac{2}{3}+\eta_1/\eta}{1+\eta_1/\eta}$

The symbol η_1 represents the absolute viscosity of the oil in poises. To apply the law, certain information must be at hand.

(a) **The temperature of the waste flow:** This value must be known in or-

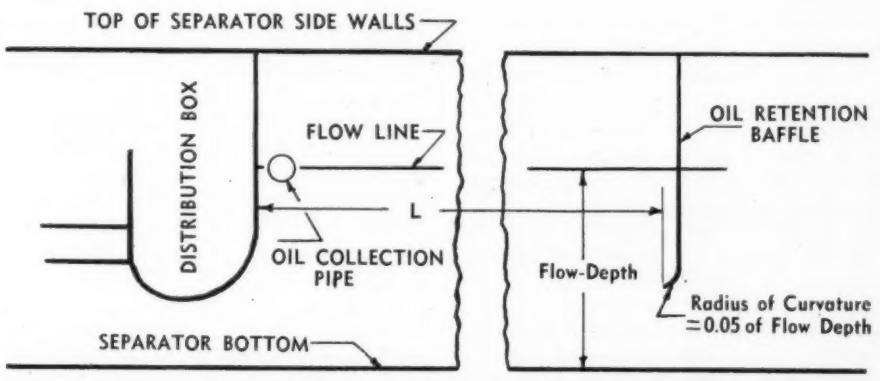


Fig. 1—Form and location of the primary section oil retention baffle, and its position as bounding the primary sedimentation basin. L = length of primary sedimentation chamber. Flight-scraper is not shown

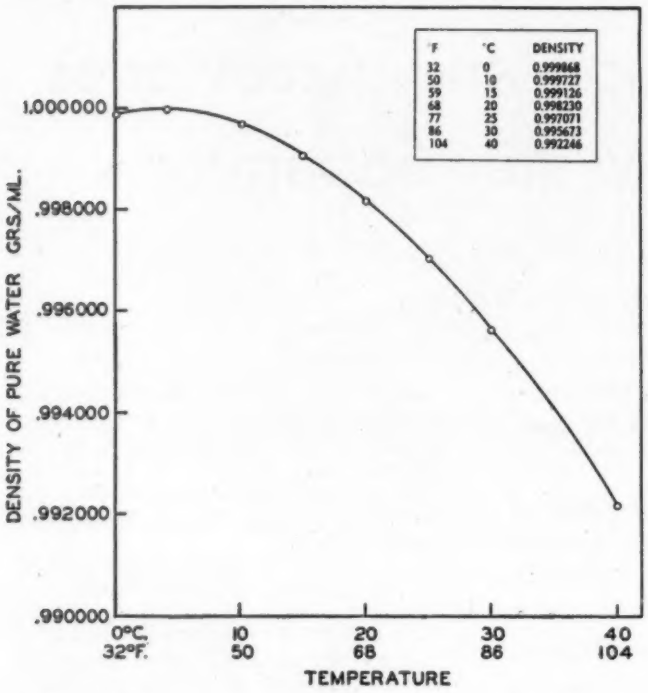


Fig. 2—Density of pure water, in grams per milliliter

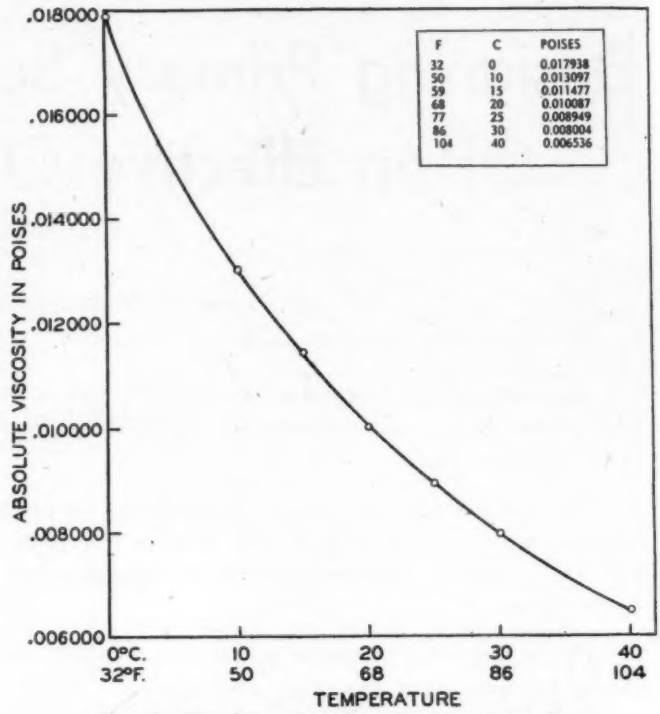


Fig. 3—Absolute viscosity of water, in poises

der to calculate the density of the water in the waste and of the oil to be separated and retained. This temperature also will affect the viscosity of the water and oil. In some regions there may be little change in seasonal temperatures; the range may be narrow. If the range does not exceed about 15° F., the median or mode of a series of temperature observations (i.e., not less than 20 observations in each distinct seasonal period) can be established and used in design. But if the range spread is greater than 15° F., the length should be calculated on the basis of the maximum and minimum temperatures, and the greater length used.

(b) **The density of the oil to be separated and retained:** Here again a range of values will be encountered, but in this case the greatest density value (i.e., that which most nearly approaches the density of water) which occurs with reasonable frequency (e.g., 10% of the number of tests made) is the value to be used for design.

For both temperature and oil density a sufficient number of samples should be collected, at intervals sufficiently short to assure that all reasonably probable conditions will be covered. Each sample should represent the entire waste flow. The sample should be settled for one hour, after which the separated oil can be removed for test. Material which settles on the bottom of the container also should be examined for quantity by estimation; and also for quality, principally for organic matter. There should be particular attention to the presence or absence of any heavy oil.

Density determinations should be made at the design temperature, if possible. Otherwise, the determination can be made at some convenient temperature and converted to API degrees for reconversion to the density at design temperature. This conversion and reconversion should be performed accurately. The final value should be regarded as grams per milliliter, since the rate of rise calculation is in the metric system.

(c) **The density of the water portion of the waste:** Although the density of pure water varies little with change in temperature, there may be considerable variation in the density of waste water, as a result, for example of dissolved solids. Consequently, the density of the water portion of the waste should be determined directly at the temperature to be used in the separator design.

If the density cannot be determined at design temperature, the slope of the curve for pure water can be used as a guide to change of density of the water portion with change in temperature (Fig. 2). Thus, the water from which the oil has been separated can be used for the density determination. The temperature at which the determination is made should be recorded so that any subsequent change can be accomplished. The final density value should be regarded as grams per milliliter.

The density of pure water should not be used for calculation of sedimentation basin length, for it may indicate an unnecessarily long basin, particularly if the water portion of the waste is brackish or is sea water.

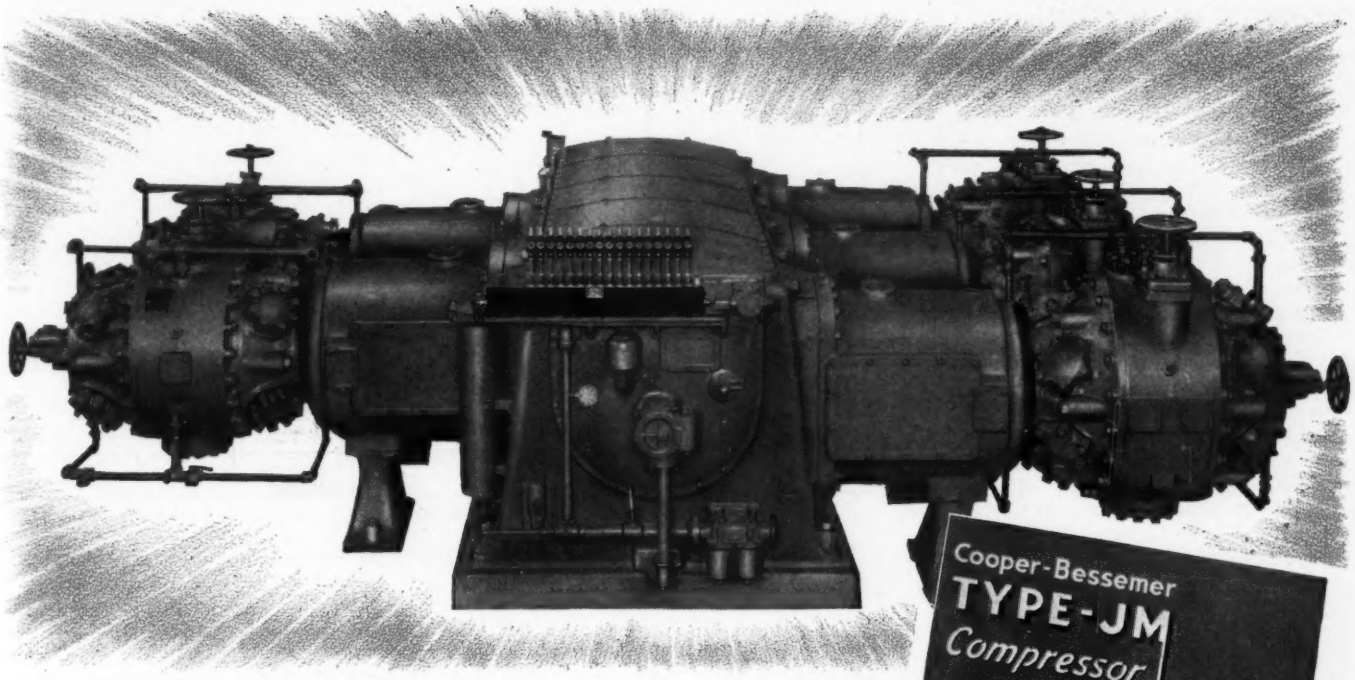
It is of great importance that an ample number of water density values be obtained so that all probable conditions are covered. The density selected for design should be the lowest which occurs with reasonable frequency (e.g., 10% of all the values).

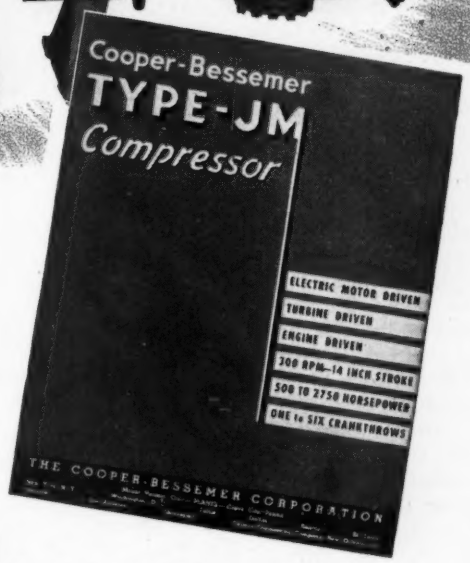
(d) **The absolute viscosity of the oil to be separated and retained:** This value can be determined from the oil collected for density value. It may be determined directly or from some corresponding value in other terms, or at another temperature. Calculation from corresponding values should be carried out accurately. The final value for use in design should be the absolute viscosity in poises at the design temperature.

(e) **The absolute viscosity of the water portion of the waste:** This value may be obtained from samples collected for oil density. It is desirable to use a rotational type of viscosimeter. The determination may be direct, at the design temperature, or calculated from corresponding values at other temperatures. The curve for pure water may be used as a guide in such calculations, and the final value should be poises at the design temperature (Fig. 3).

The absolute viscosity of the water is of great importance, and should be determined carefully. It affects determination of the rate of rise of an oil globule in two ways. It reflects not only the influence of the viscosity of the water portion of the waste, but also the effect of finely divided suspended matter and turbidity upon this viscosity. This effect on viscosity, and incidentally upon density, is shown clearly in Fig. 4 for two different types of turbidity.

These data, when properly substituted in the equation of Stokes' Law will give





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the rate of rise of a globule of oil 0.02 cm. diameter. The result will be in terms of centimeters per second, which can be converted to feet per minute by use of the factor 1.969. This value constitutes one side of the rectangle previously mentioned.

The other side of the rectangle is the value of the average velocity of flow through the separator section. To obtain this value there must be known the:

(f) **Reynolds number to be used in the design:** This can be selected from the curve provided(170). It will depend upon the density of the oil to be separated and retained, at the design temperature, converted to API degrees. The curve referred to above shows API degrees instead of density because the former is a much more familiar value and offers certain advantages in recognizing oils, even though it requires the additional conversion.

(g) **Hydraulic radius of the section:** This can be calculated from the dimensions of the standard separator (i.e., width and depth), or from the dimensions found to be necessary from design.

(h) **Kinematic viscosity of the water portion of the waste:** This can be determined directly from the samples taken and settled for oil density, or can be calculated from the absolute viscosity. It should be evaluated at the temperature to be used in design, and for application here should be in terms of square feet per second. With these values known, and using the formula:

$$R=\frac{VR}{v} \text{ or } V=\frac{Rv}{R}$$

it is possible to evaluate the average velocity of flow, V. Then, the time required for the globule to rise through the complete depth of flow in minutes, multiplied by the average velocity in feet per minute, will give the length of the primary sedimentation basin in feet.

Since the discussion thus far has provided the methods for determining the principal dimensions of the primary sedimentation basin, and since the secondary section of the separator is designed from the dimensions of the primary section, it seems useful to present an example of primary section design at this point. The example presented is taken from the design of a separator now in use. For obvious reasons the basic observations have been changed slightly.

Basic Data from Survey Observations

1. Load: From utility records checked by weir measurements to include storm run-off and including 500,000 gals./day for future plant expansion, a factor which always should be considered:

Process water .. 9,650,000 gals./day
Storm run-off .. 4,300,000 gals./day
Total load ....13,950,000 gals./day

This daily load is equivalent to 1292 cu. ft./min. For design purposes use 1295 cu. ft./min. as maximum load.

(Note—It will be noticed that no allowance has been made in this load for water from fire streams. In these days of gas-tight tanks, welded lines, and well organized fire prevention and fire fighting in refineries, the probability that storm and fire will occur together is remote. Usually the storm run-off load will exceed the fire stream load. Therefore, the run-off load serves both items, and no allowance for fire streams, in addition to the run-off, is included).

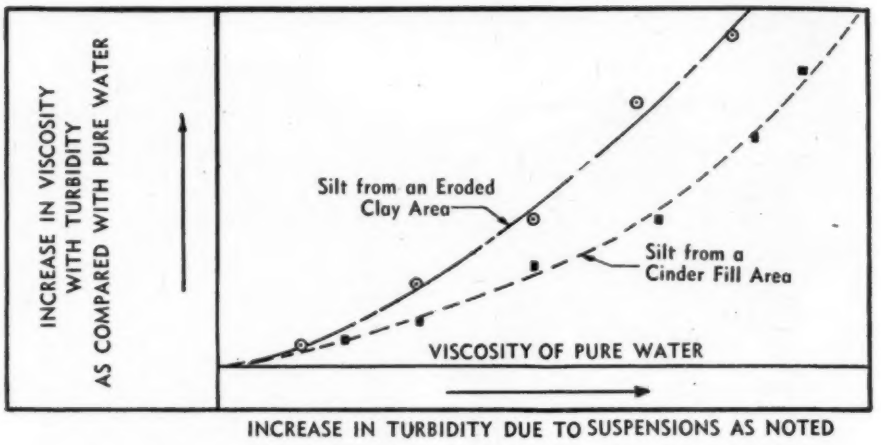

INCREASE IN VISCOSITY WITH TURBIDITY AS COMPARED WITH PURE WATER
Silt from an Eroded Clay Area
Silt from a Cinder Fill Area
VISCOSITY OF PURE WATER
INCREASE IN TURBIDITY DUE TO SUSPENSIONS AS NOTED

Fig. 4—Effect of two types of turbidity on the viscosity of pure water

2. Temperature: Number of observations made, at a scheduled time once each 8-hr. shift, for three periods estimated to cover all seasonal conditions—270. Maximum—114° F.; minimum—98° F.; mode —104° F.

(Note—The mode is the value which appears among the observations most frequently).

3. Oil density observation: Samples collected at time of each temperature observation. Of the samples collected, the highest value which occurred in 10% of the densities was 0.882 at 76° F. Using this value as a specific gravity, a procedure which will provide sufficient accuracy, the equivalent API gravity at 76° F. is 28.9°, or 27.9° API at 60° F., or 30.7° API at 104° F., the design temperature. For present purposes the design value is 30.7° API, which is applied to Fig. 2(170), and which is equivalent to a density of 0.8724. R for this density is 15200.

(Note—The above conversions can be worked out quickly from a table(171) of API gravity equivalents).

4. Oil viscosity observations: From 270 samples as in 3 above the average absolute viscosity is 0.0623 poises at 104° F.

(Note—The average viscosity is used here because the heavier oils are affected but little. The effect is related to the lighter oils mostly, and is not great in any case).

5. Water density observations: From the 270 observations the mode of the lowest 10% was 1.0056 at 74° F., giving a differential from the density of pure water at 74° F. of 0.008154. Applying this differential to the pure water density curve shown in Fig. 2, the design density will be:

Density of pure water at 104° F.	0.992246
Plus the differential	0.008154
Design density of the water portion of the waste at 104° F.	1.0004

6. Water viscosity observations: The average viscosity of the 270 values observed at 104° F. was 0.006536 poises. This becomes the value for design. It is the absolute viscosity value.

7. Observations of the kinematic viscosity of the water: This is derived from the absolute viscosity in poises by dividing by the density in grams per milliliter. The quotient will be the kinematic viscosity in Stokes, the cm., gr., sec., or metric unit. This value can be converted to sq. ft. per second by either dividing by 929.0, or multiplying by 0.0010764. Thus:

(0.006536 ÷ 1.004) ÷ 929.0 = 0.000007033 sq. ft. per second, the kinematic viscosity to be used in the design.

Actual Design Procedure

All data required for design are now available as outlined above, and actual design procedures can be started. The procedure will be presented in steps. The first step will be the determination of the capacity of a standard section 20 ft. wide and 8 ft. deep for a waste flow having the above characteristics. This can be done by finding the velocity from the equation for the Reynolds number:

$$R=\frac{VR}{v} \text{ or } V=\frac{Rv}{R}$$

R = 160 ÷ (8 + 20 + 8) = 4.44, the hydraulic radius. Then, by substituting,

$$V=\frac{0.000007033\times 15200}{4.44}$$

$$=0.024 \text{ ft./sec.}$$

0.024 × 60 sec./min. × 160 sq. ft. = 230 cu. ft./min., the capacity of a stand-

ard section. For the load to be imposed, i.e., 1295 cu. ft./min., there are indicated 1295 ÷ 230 = 5.6 standard sections.

The problem of providing distribution for a fractional parallel section, i.e., the delivery of the proportional part of the flow to this fractional section when all others are standard, is an extremely difficult one. And if the distribution is not proper, the fractional section, or perhaps even the standard sections, may be overloaded. It is highly preferable, therefore, to design all parallel sections of the same size. In this example there will be 6 parallel sections, each somewhat smaller than a standard section. Each will have a capacity of 1295 ÷ 6 = 216 cu. ft./min.

It now becomes necessary to find the length, depth, and Reynolds number for this reduced section. This is done by employing the load ratio already explained:

$$\sqrt[2.5]{Q} : \sqrt[2.5]{Q_{model}} :: \sqrt{A} : \sqrt{A_{model}}$$

$$\sqrt[2.5]{230} : \sqrt[2.5]{216} :: \sqrt{160} : \sqrt{A_m}$$

$$8.804 : 8.586 :: 12.65 : \sqrt{A_m}$$

$$\sqrt{A_m} = 12.34, \text{ or } A_m = 152.27$$

$A = 2.5d^2$; $152.27 = 2.5d^2$; d = 7.8 ft. = the depth. The width, b, = 2.5 × 7.8 = 19.5 ft.

The section size, therefore, is 19 ft.-6 ins. wide by 7 ft.-8 ins. deep, equivalent to 152 sq. ft. area. This area is loaded with a flow of 216 cu. ft./min., or 3.6 cu. ft./sec. The average velocity will be 0.023 ft./sec., and the hydraulic radius 4.33. From these data the Reynolds Number can be calculated:

$$R = \frac{VR}{v} = \frac{0.023 \times 4.33}{0.000007033} = 14160$$

which can be checked by reference(172).

The next basic dimension of the primary sedimentation basin to be determined is the length, but to do so it is necessary first to find the rate and time of rise of an oil globule by use of the Stokes' law equation:

$$V = \frac{1}{k} \cdot \frac{2g(\rho - \rho_1)r^2}{9\eta}$$

in which $k = \dfrac{\frac{2}{3} + \eta_1/\eta}{1 + \eta_1/\eta}$

Solving the latter equation first:

$$k = \frac{\frac{2}{3} + 0.0623/0.00654}{1 + 0.0623/0.00654} = 0.968$$

Then:

$$V = \frac{1}{0.968} \times \frac{2 \times 980.16 \times (0.8724 - 1.0004) \times 0.0001}{9 \times 0.006536}$$

$$= 0.44 \text{ cm./sec.}$$

$$= 0.44 \times 1.969 \text{ (conversion factor)}$$

$$= 0.866 \text{ ft./min.}$$

The sedimentation basin in the example is 7.8 ft. deep from bottom to flow line (i.e., flow depth). Therefore,

7.8 ft. ÷ 0.866 ft. = 9 min.,

the time required for the 0.02 cm. diameter globule of oil to rise through the flow depth. But due to the average velocity of the flow of waste through the basin there will be a constant translation action of (0.024 ft./sec. × 60) 1.44 ft./min., so the length of the basin will be 1.44 (ft./min.) × 9 (min.) = 12.96 ft., or, for design purpose, 13.0 ft. This length is the distance between the downstream wall of the distribution box and the upstream edge of the oil retention baffle.

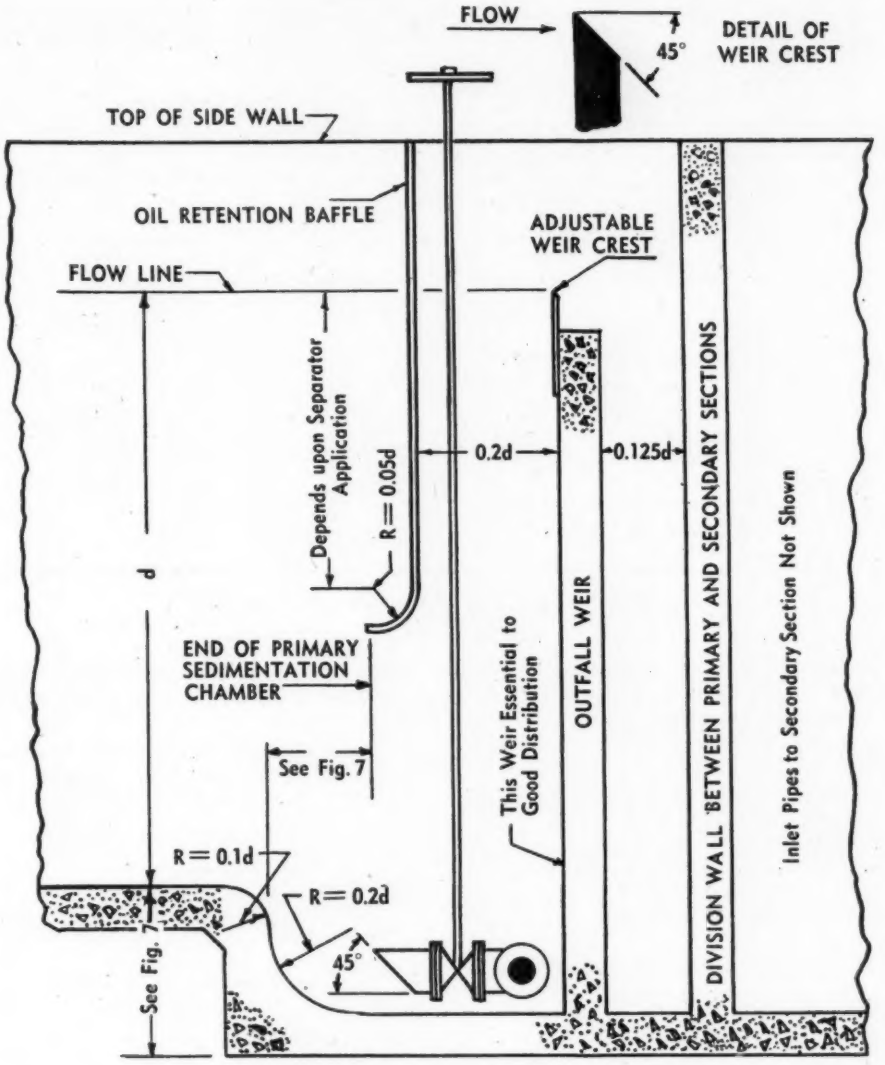


Fig. 5—Details of outlet end of primary section

Oil Retention Baffle

Next step in the design is the development of accessory equipment, which includes the oil retention baffle, the flow-line control baffle, the oil collector pipe, and the flight-scraper and cleaning equipment.

The oil retention baffle has as its purpose the retention of the layer of oil which separates and floats on the water surface. If this were not held back by some impervious wall extending through the surface, and down into the flow, it would pass over the flow-line baffle and out of the primary section. Probably the best understanding of the construction of the oil retention baffle for the first stage will be had from Fig. 1. The distance which the baffle extends below the surface of the flow is a matter of separator application, for it will control the amount of oil the separator will retain in an emergency.

If the separator will be subject to emergency loads of large quantities of oil, or if it is the final step in the protection of a body of surface water, the baffle should be as deep as possible. There is a limit to this, however. The baffle never should extend into the flow to a depth greater than one-half the flow depth. A greater restriction of the space under the baffle will cause the outlet-end effect to be influential too far forward in the sedimentation basin because of the increased velocity through the restriction.

If the separator is applied to retain a small quantity of oil from a constant flow of waste, and the probability of a heavy, sudden load of oil is remote, the baffle preferably need extend downward into the

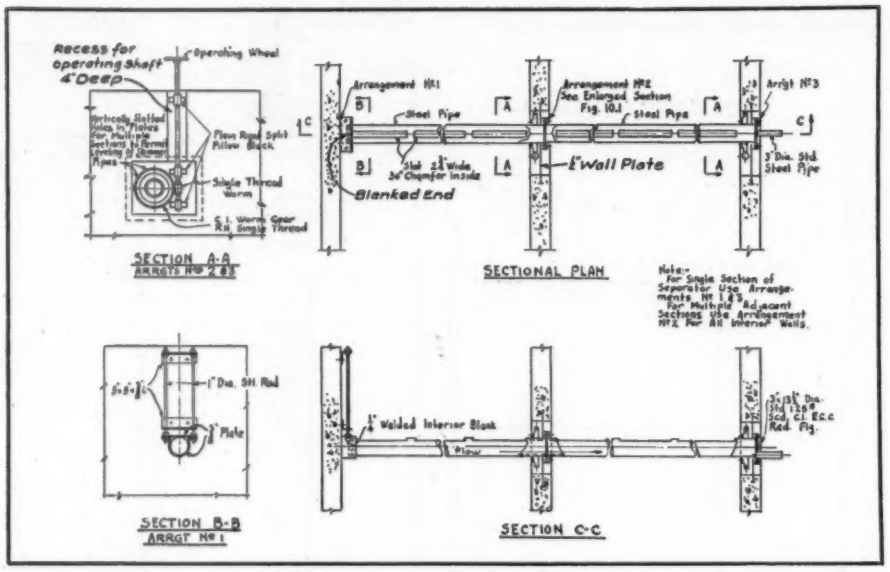

Recess for operating Shaft 4" Deep
Operating Wheel
Vertically Slotted Holes in Plates for Multiple sections to Permit Lowering of Scraper Pipes
Plain Rigid Split Pillow Block
Single Thread Worm
C.I. Worm Gear R.H. Single Thread
SECTION A-A
Arrangement No 1
Steel Pipe
Blanked End
Arrangement No 2 See Enlarged Section Fig. 10.1
Steel Pipe
Arrgt No 3
3" Dia. Std. Steel Pipe
Std. 2" Wide 3/4" Chamfer Inside
1/2" Wall Plate
SECTIONAL PLAN
Note:- For Single Section of Separator Use Arrangements No 1 & 3 For Multiple Adjacent Sections Use Arrangement No 2 for All Internal Walls.
1" Dia. Std. Rod
1" Plate
SECTION B-B Arrgt No 1
1/2" Welded Interior Blank
Flow
SECTION C-C

Fig. 6—Design of typical oil-collecting pipe

flow only one-fourth, or one-fifth of the flow depth. It always should be deep enough to catch and retain a 0.02 cm. diameter globule of oil, the rise of which originates immediately below the downstream face of the distribution box, on the separator bottom.

Regardless of the depth of the baffle, the bottom is curved in an upstream direction as shown in Fig. 1. The radius of this curvature is 0.05 of the flow depth. Above the curvature the baffle is vertical, and extends to the top of the separator side-walls. If there is any likelihood that the separator may settle unevenly, at some point above the flow surface there should be an adjustable joint, or other device, by which the bottom edge of the baffle can be leveled. The joint between the baffle and the side-walls should be made tight by packing or other means. The baffle should not be sealed into the side walls unless there is absolute assurance it will remain level.

Flow-Line Control Baffle

The flow level control or outlet baffle of the primary section is important, particularly because it functions to maintain the design depth of flow in the sedimentation basin, and also because of its relation to the flow over the distribution weir of the distribution box. There are three elevations to consider; they are the height of the outlet baffle above the floor of the separator, the height of the flow-line above the floor, and the height of the distribution weir (of the distribution box) above the floor. They are related in this way.

The flow-line elevation is the sum of the height of the weir crest of the outlet baffle above the floor of the separator, plus the head of the flow over this weir crest. The flow-line should provide the design depth of flow in the basin and yet permit free fall flow from the distribution weir at the front end. To properly relate these elevations it is necessary to estimate the head on the crest of the outlet weir.

To estimate this head the Francis equation for rectangular weirs without end contractions is used in its simplified form:

$$Q = 3.33LH^{3/2}$$

in which:

Q = the flow in cu. ft./sec.,
L = width (i.e., length) of the weir in feet,
H = head on the weir in feet.

By transposition this equation can be solved for H:

$$H = \sqrt[3]{\left(\frac{Q}{3.33L}\right)^2}$$

Continuing the example data previously used, i.e., a flow of 1295 cu. ft./min. on a 19.5-ft. wide (or long) weir, these data can be reduced and substituted:

$$H = \sqrt[3]{\left(\frac{3.6}{3.33 \times 19.5}\right)^2} = 0.145 \text{ ft.}$$

(Note—as a precaution it is mentioned here that although the Francis equation is sufficiently accurate for application as above, it is not always accurate for estimating flow. It should be examined carefully for necessary correction before being used for that purpose).

With the head on the outlet weir established, the height of the weir above the separator bottom can be figured. The flow-line is 7.8 ft. above the bottom. But 0.145 ft. of this is head on the weir. Therefore, the crest of the weir should be 7.8 — 0.145, or 7.75 ft. above the separator bottom. Of course, the design dimension should be 7 ft.-9 in. The extra decimal places are used here to present a clear relationship. Also, since the flow-line is the datum line, the proper relationship between that and the distribution weir will have been provided, as shown previously(169).

The remaining detail of design for the out-fall weir is that of the crest, which is made adjustable so that it can be leveled readily and should be machined to a 45° bevel as shown in Fig. 5.

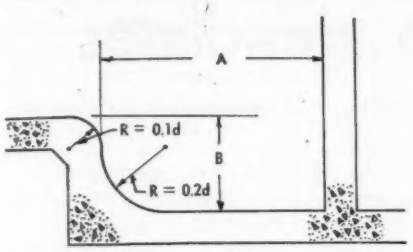
Oil Collector Pipe

The oil collector pipe is a slotted pipe of the proper size, which is suspended across the separator at the front end just beyond the distribution box, as in Fig. 1. There are several different ways by which the pipe may be supported; regardless of the method employed, there are certain conditions to be provided for. The pipe must be so designed that if a single slot is used it can be rotated sufficiently to collect oil from both the upstream and downstream surfaces of the waste flow. If two slots are used, the one on the downstream side should be the more nearly continuous, for it will collect the most oil. The upstream slot can be discontinuous, for it will be used to collect the floating oil which accumulates gradually between the collector pipe and the distribution box. Movement of the pipe, so that the skimming operation will not pick up too much water, is rotational. The rotation is accomplished by either a gear and pinion arrangement, or simply by a handle welded to the end of the pipe (Fig. 6).

The other important factor in design is that the pipe cannot be too long. When there are several separators in parallel there may be the thought that one long collector pipe will serve them all. This can, and has caused trouble. The collector pipe should be level, and the head on the flow through it cannot be great, because too much water would be collected. The viscosity of the oil at this low head can interfere with such low flow. Therefore, it is advisable to arrange the collector pipes, when several sections must be served, in a manner which will provide a discharge or draw-off at intervals not in excess of 40 ft. The draw-off can be carried within the common dividing wall between two sections, or in another suitable manner.

Flight-Scraper, Cleaning Equipment

It would require too much space and illustration in a presentation of this kind to adequately describe the installation of a flight-scraper cleaning device. Briefly, however, it consists of a series of boards, traveling in a vertical position and supported at each end by an endless chain. The chain is guided by rail-like devices on the side walls of the sedimentation basin, and by sprocket wheels at each end of the basin. At each end, one set of wheels is at the surface and one set is near the bottom. Each set of wheels, with one opposite the other, is shaft connected, with bearings in the separator walls. A low horsepower motor equipped with a chain drive actuates the mechanism, which travels at a rate of about 2 to 3



Suspended Matter in PPM.	Dimension A	Dimension B
0 to 500	0.375d	0.15d
500 to 1000	0.4375d	0.25d
1000 to 2500	0.5000d(1)	0.3125d(1)

(1) Should Not Be Exceeded.

Fig. 7—Sludge reservoir for primary section, with dimensions for various amounts of suspended matter

ft./min. The boards extend several inches above and below the flow-line, and at the surface they move counter to the flow.

Along the bottom of the separator the boards move with the flow, and with very little bottom clearance. They move the accumulation of bottom settlings toward the outlet end of the basin. These boards also act to retard and destroy any bottom current short circuiting. The equipment is operated only as necessary.

In the example used earlier, mention was made of estimating the quantity of sludge which settled to the bottom. This will be an indication of the space which should be provided in the sludge reservoir. Where the amount is relatively small, the dimensions shown in Fig. 7 will be satisfactory. The figure also shows the details of the design.

A means for removal of the sludge also must be provided. For this purpose several types of pumps operated from above the flow have been used. Quite often pumps of this type have been subject to mechanical difficulties, although some have given satisfactory service. The pumps ordinarily take suction from a header extending across the sludge reservoir with valve controlled openings (branches) at intervals.

Probably the most satisfactory method for sludge removal is that using a pump pit at the side or end of the separator. This method is particularly well suited to plants using a water supply which is heavily silted. The same type of header (i.e., with valved branches) is used, but it is extended through the side walls to a pit designed for the purpose. Suction is taken from this pit by a slurry pump in an adjoining dry pit, which is at an elevation to permit a *positive* suction.

References

(169) "Disposal of Refinery Wastes," W. B. Hart, PETROLEUM PROCESSING, 2 (4), April, 1947, Fig. 7.

(170) *Ibid*, Fig. 2.

(171) "New and Revised Tag Manual for Inspection of Petroleum," 18th Rev. Ed., edited by R. M. Wilhelm, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

(172) "Disposal of Refinery Wastes," W. B. Hart, PETROLEUM PROCESSING, 2 (4), April, 1947, Fig. 3.

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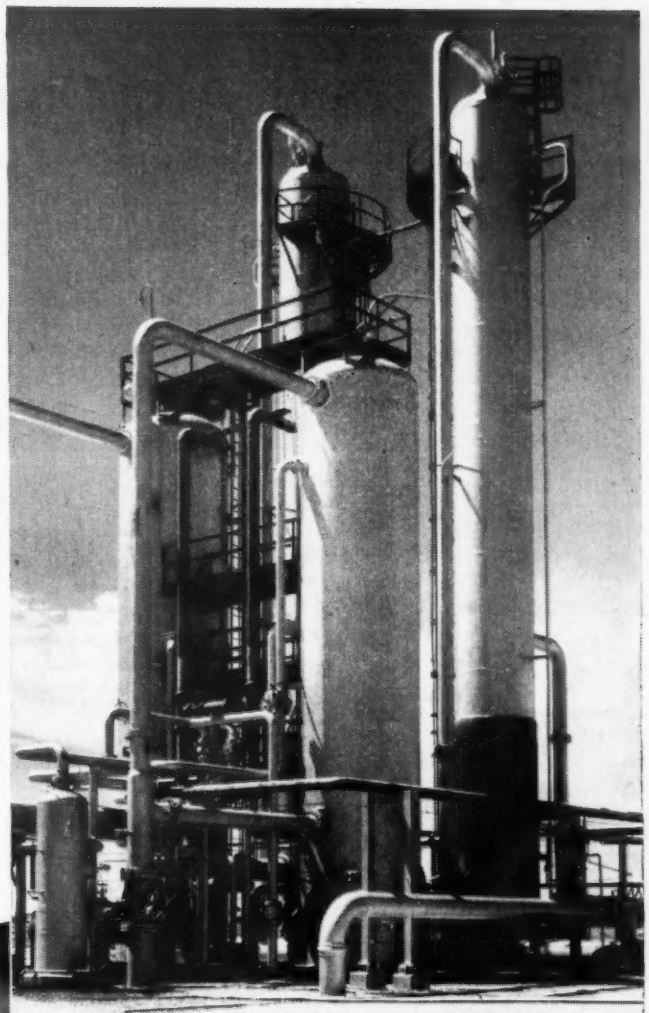

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PERSONALS

Petroleum Technologists in the Headlines

Carl S. Miner, head of Miner Laboratories, Chicago, has been elected a director of Universal Oil Products Co. A native of Iowa, he attended Coe College and the University of Chicago, graduating from the latter in 1903 with a B. S. degree in chemistry. After serving as a research chemist for Corn Products Refining Co., he established the Miner Laboratories in 1906.

Mr. Miner

Mr Miner is credited with many scientific achievements and in 1940 was the recipient of a Modern Pioneer Award from the National Assn. of Manufacturers. During the war he was a consultant to the Rubber Survey Committee and a member of the Chemical Referee Board, Office of Production Research and Development and of the War Production Board.

• • •

E. J. Berghausen, junior technologist for Shell Chemical Corp., has been transferred from San Francisco to New York.

Five junior chemists at the company's Torrance plant have been promoted to chemist. They are: **L. R. Donkle, L. C. Norton, Dorothy J. Schroeder, J. F. Self,** and **C. V. Samuelson.**

• • •

Dr. Claude C. Peavy has been appointed chief engineer of Houdry Process Corp., Phila. He has been with the company for over a year coming from Socony-Vacuum Oil Co., where he was chief process engineer in the refinery engineering division.

Dr. Peavy

Prior to his five years of service with Socony, Dr. Peavy had been an engineer for the E. B. Badger & Sons Co. for nine years. With Badger he traveled to many countries installing and constructing refinery units. He also worked on the design for the first Houdry Fixed-Bed Catalytic cracking units.

With the promotion of Dr. Peavy, other changes were also made by Houdry. **Harmon J. Monnik** was made chief of the mechanical engineering department, and **William C. Dickermen** was placed in charge of the process design department.

Development engineering will continue to be carried on at the Houdry Laboratories near Marcus Hook, Penna., under the direction of **Raymond C. Lassiat.**

• • •

Wilson De Long, chemist and engineer in Shell Oil Co.'s Wood River, Ill. research laboratory, has been transferred to the Thornton Research Center in Chester, England, to remain for an indefinite period acquainting himself with research and testing techniques there. He has been with Shell 13 years, starting in the control laboratories as a tester.

Other research laboratory shifts at Wood River include:

R. A. Burdett, former senior chemist, to assistant chief research chemist.

L. W. Griffith, former senior engineer, to assistant chief engineer at the laboratory.

L. W. Taylor, former control laboratory chemist in charge of gas analysis and analytical distillation laboratory.

• • •

Dr. Paul H. Carnell has resigned his position in the research department of Phillips Petroleum Co., Bartlesville, Okla. He is now in charge of research and development at the Leonard Refineries, Inc., Alma, Michigan.

• • •

Edwin J. Barth, well-known petroleum technologist, has recently become associated with A. Johnson & Co.' Refineries in Sweden as petrochemical and refining expert, working on petroleum processes and product development.

• • •

Frederic L. Matthews has been appointed associate director of research of Monsanto Chemical Co.'s Merrimac division at Everett, Mass. Dr. Matthews' former post of coordinator of petroleum additives in Monsanto's organic chemicals division will be filled by **Harry W. Faust,** at present, a group leader in petroleum chemical research in the division. Mr. Faust's position will be filled by **J. F. Palmer,** research chemist in the petroleum chemical research group.

• • •

R. J. De Largey has been transferred as plant superintendent of Shell Point from his position of chief technologist at Houston for the Shell Chemical Corp.

Manufacturing department promotions and transfers announced by the Chemical Corp., include **H. Q. Dugid,** from senior engineer in the main office to chief engineer, Houston; **I. I. Schultz,** from senior technologist in the main office to chief technologist, Shell Point; and **H. I. Wolff,** chief technologist, from Shell Point to Houston.

J. N. McClure, who was appointed manager of the Petroleum Division of Elliott Co. a year ago, has moved his headquarters from Houston, Texas, to Tulsa, Okla.

Mr. McClure will also take on the duties of manager of the Tulsa district.

Mr. McClure

A graduate of Georgia Tech, Mr. McClure joined the Elliott Company in 1923. He has served as field engineer in the Philadelphia, St. Louis and Tulsa offices before becoming Kansas City district manager in 1941.

• • •

The research department at Stanolind Oil and Gas Co., Tulsa, has just acquired three new men. **Dwight B. Mapes** has joined the research department as process research group supervisor. He was formerly with Mid-Continent Petroleum Corp., Tulsa, as solvent processing and lubricating oil supervisor.

Dr. Frank G. Pierce also has joined the process research group. Dr. Pierce was formerly with American Machine and Foundry Co. in Brooklyn, New York. **Mr. D. J. Schrecengost** is a newly arrived chemical engineer from Oak Ridge, Tenn.

• • •

Election of **W. W. Keeler** to vice president in charge of refining for Phillips Petroleum Co. is the culmination of a 16 year career in Phillips refining department.

Mr. Keeler has been with Phillips since 1924. His first position was in the engineering department while still a student at the University of Kansas. He worked at various times, both at the Kansas City and Borger refineries as chemist, control chemist, process engineer, chief chemist, night superintendent, assistant manufacturing superintendent and chief process engineer.

Mr. Keeler

He was made technical assistant to the vice president in 1943, and has been manager of the refining department since 1945.

Robert F. Strohecker has returned to The Texas Co.'s Beacon, N. Y., laboratories as a mechanical engineer. He has just received his Masters degree from Northwestern University. Two new chemists have been assigned to the laboratories at Beacon, they are: **William Henoch,** a Northwestern University Graduate, and **R. W. Mottern,** formerly with Tennessee Eastman Corp.

° ° °

Louis Puneau, president of the Permanent Council of World Petroleum Congresses (London), has been named an adviser on foreign business to Houdry Process Corp., in Paris.

° ° °

Arthur M. Mahoney was recently relieved of his duties as senior technologist at Shell Oil Co.'s Wood River, Ill., refinery to become assistant superintendent of the Montreal refinery of Shell Oil Co., Canada.

Mr. Mahoney first came to Wood River in June, 1937 as a technical assistant. In May, 1941 he was transferred to the Anglo-Egyptian oil fields in the Middle East, returning to Wood River in Sept. 1946 as senior technologist.

Technical Meetings For Oil Men

June

5-6, Pennsylvania Grade Crude Oil Association, Annual meeting, William Penn Hotel, Pittsburgh.

12-14, American Chemical Society, 10th National Organic Chemistry Symposium, Division of Organic Chemistry, Boston, Mass.

15-20, American Society of Mechanical Engineers, Annual meeting, Chicago.

16-20, American Society for Testing Materials. 50th Annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

23-25, American Chemical Society, 15th Midwest Regional meeting, Hotel President, Kansas City, Mo.

July

29, API, Lubrication Committee, Executive Committee, Skytop Inn, Skytop, Pa.

September

1-4, American Society of Mechanical Engineers, Fall meeting, Hotel Utah, Salt Lake City, Utah.

8-9, American Society of Mechanical Engineers, Industrial Instruments and Regulators Division, Chicago.

8-12, Instrument Society of America, 2nd National Instrument Congress and Exhibit, Stevens Hotel, Chicago.

15-19, American Chemical Society, 112th National meeting, New York.

October

6-8, American Society of Mechanical Engineers, Petroleum Mechanical Engineering, Conference, Rice Hotel, Houston.

10, California Natural Gasoline Association, Fall meeting, Ambassador Hotel, Los Angeles.

16-18, National Lubricating Grease Institute, 15th Annual meeting, Edgewater Beach Hotel, Chicago.

20-22, American Society of Mechanical Engineers, Fuels Division, Joint meeting American Society of Mining and Metallurgical Engineers, Coal Division, Cincinnati, Ohio.

21-25, Pacific Chemical Exposition, Section of American Chemical Society, San Francisco Civic Auditorium, San Francisco.

M. W. Kellogg, founder and chairman of the board of M. W. Kellogg Co., has been elected to the newly created post of chairman of the board of the subsidiary Kellex Corp.

H. R. Austin, formerly executive vice president, succeeds Mr. Kellogg as president of Kellex. He will hold this post concurrently with his position as president of Kellogg Co. Creation of the new Kellex post, board chairman, was made necessary by its rapidly expanding activities in the field of atomic power and guided missiles.

° ° °

Samuel S. Todd, physical chemist with the U. S. Bureau of Mines, has been transferred from the Petroleum Experiment station in Bartlesville, Okla., to Pacific Experiment Station in Berkeley, Calif.

° ° °

Theodore Vermeulen, Shell Development Co. chemist, has accepted an appointment as assistant professor in the department of chemistry at the University of California at Berkeley.

° ° °

H. H. Jones, formerly superintendent of gasoline plant operation for Phillips Petroleum Co. at Bartlesville, is now chief engineer for the Dresser Engineering Co., Tulsa, and will work particularly on the design of compressor stations and related construction. He reports having been well initiated as a Tulsan: Shortly after moving there his car was badly smashed in an automobile accident although his wife, who was driving, escaped without serious injury; then his little boy was bitten by a dog. Unlike most new Tulsans, however, he found a house without great difficulty.

° ° °

Listed among the promotions to foreman and assistant foreman at the Sun Oil Co.'s Marcus Hook, Pa., refinery were: **Charles L. Cooper,** Zone 5; **J. Harvey Sykes,** Construction division; **Herbert G. Bagley,** Machine shop; **Leroy Pettit,** Refinery boiler shop; **Fred E. Ruby,** Plant 14, Solvent Refining, **Robert F. Gourley,** Plant 14; **Joseph E. Rhoads,** Plants 15-1, 2, and 3; **Alex Schwan,** Plant 15-2, Gas recovery section; **Frank G. Gilcken,** Plant 14, Solvent refining; **George D. Reed,** Machine shop; and **James J. Honan,** Plant 15-1.

° ° °

Ronald E. Meyer, has left the Celanese Corp. to join the Warren Petroleum Corp., Tulsa. He will be in charge of the research and development laboratory at Tulsa.

° ° °

H. M. Nelly, Jr., Houston, is now vice-president of the Refinery Maintenance Co. He was formerly manager of the Petroleum Division of J. F. Pritchard & Co.

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Petroleum Processing announces this new classified section as a regular feature for the convenience of its readers. Classified rates are shown in the accompanying box.

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EDITORIAL COMMENTS

WIDENING HORIZONS

Gasoline Plant Investments Are Practical Conservation

WHILE representatives of the public regulatory agencies clamor about the "waste" of natural gas in southwest, the oil and gas companies have been steadily improving their technology and investing large sums in plants to conserve the gas produced along with the oil in oil fields.

The programs now under way and those contemplated, if carried out, will reduce to the practicable minimum the amount of "flare" gas not utilized in some manner to further the cause of conservation. The regulatory agencies, however, in part at least, can hold back or defeat this constructive conservation movement by holding the price for such gas as can be sold at such a low figure as to make it economically impracticable for the companies to carry out their complete conservation programs.

The extent to which one company, Humble Oil & Refining, has already provided the means for conserving casinghead gas produced with the oil is described in an article by two of its engineers in a late issue of the "Humble Way." The company had embarked on its program before the war. In the war period, construction of plants for the extraction of liquid fractions from the gas, and other facilities of gas conservation projects was of necessity greatly curtailed.

At the end of the war, however, of 408 million cubic feet of casinghead produced daily by Humble, 198 million feet was being utilized and 210 million feet was being flared. Humble's postwar program to date, including facilities now complete or under construction, calls for the utilization of an additional 110 million feet, increasing total utilization to 75% of its produced casinghead gas. Projects still in the planning stage call for utilizing another 69 million feet and, when developed, will increase Humble's utilization of its casinghead gas to 90% of its production. Of the remaining gas flared, some is in fields in which this company is not a major operator and some is from fields in which the small volume produced, high sulfur content, remote location or other factors make economical conservation impossible.

The cost to Humble of gas conservation projects completed since the end of the war is $4,000,000 and the total cost of its program will be $10,000,000. This is for conservation, through utilization, of casinghead gas only. Other companies, including some relatively small operators, are also today investing large sums in gasoline plants and other facilities for the utilization of gas, including both casinghead gas and dry gas. Interstate Oil Compact authorities say that 15 major gasoline extraction plants were built in Texas alone during 1942-45, at a cost of almost $27,000,000.

This large and growing investment in gasoline plants as a principal feature of the gas conservation programs, is being made by the oil and gas companies from their own funds. It makes possible an important conservation of our liquid hydrocarbon resources and adds materially to our motor gasoline supply. The liquid fractions recovered, however, can represent at the most only a few per cent of the volume of the gas handled. The economic practicability of the entire conservation project in many instances must be based on the price received for the residue gas when it is marketed.

The regulatory agencies should recognize this principle in fixing the price for the gas passed on to consumers after it has been processed, if it is desired to encourage fullest application of this practical medium for conservation. The Federal Power Commission is impeding, not furthering, the movement by going on the theory that what the companies earn from their investments in gas conservation facilities in large part should be passed on to the consumer in the form of a lower price for the residue gas he uses.

READERS' comments and opinions will be welcomed by the editors of PETROLEUM PROCESSING, 1213 West Third Street, Cleveland 13, Ohio

How Near Is Fuel Injection?

REPORTS that fuel injection or fuel metering systems would soon be applied to land vehicles has prompted informal inquiries among informed automotive engineers. In brief, the situation seems to be that considerable experimental work is going on, particularly with the application of fuel metering devices on trucks and buses. The problem is recognized as the developing of an injection apparatus that will last and work satisfactorily as long as present carburetors, the fuel metering equipment being complicated, delicate and to date expensive. Manufacturers of fuel injectors for Diesel engines would like to be able to install their apparatus on gasoline engines. Concerns who make injectors for present aircraft engines would like to see them installed on land vehicles.

"The truck and bus industry is seriously investigating all types of available injection systems as a means for improving engine performance and obtaining better fuel economy," one authority recently told a sectional SAE meeting. "Engineers have expressed the opinion that, as soon as a moderately priced injection system has proven its reliability, it will be widely adapted in commercial automotive vehicle engines.

"The availability of a simple reliable injection system may affect the basic construction of truck and bus engines as it simplifies the development of a satisfactory two-cycle spark ignited engine and would increase the reliability of the air-cooled aircraft type of engine. These engine types are attractive for road vehicles because of the weight-saving possibilities they afford."

The present necessity in England and on the Continent of using other fuels than gasoline has caused reconsideration there of fuel injection systems for automobile spark-ignition engines, but the work is reported not sufficiently advanced to give useful information. Cost and accurate metering for injection systems for small cylinders is reported the principal problem.

The status of fuel injection for gasoline engines in land vehicles in this country is summed up by one authority as: "Holds interest for the long trend but must be moderately priced, simple and serviceable in the field. Offers certain advantages and also some problems to be solved. There is no system today for ground vehicles meeting these requirements."

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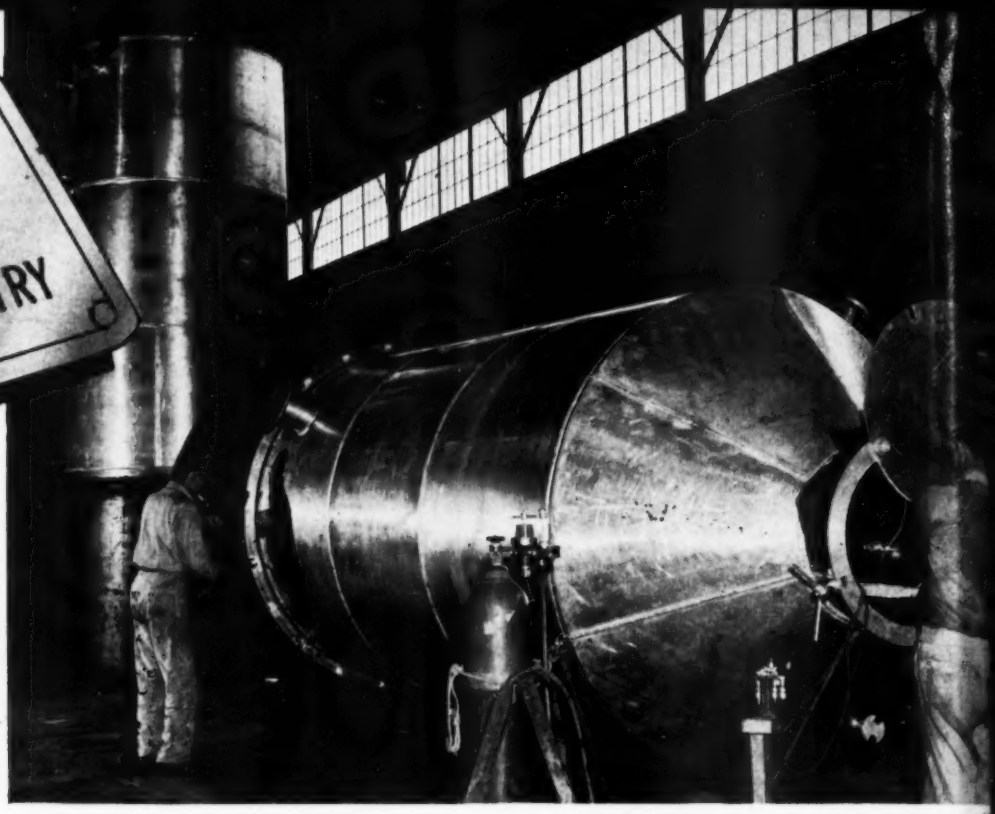
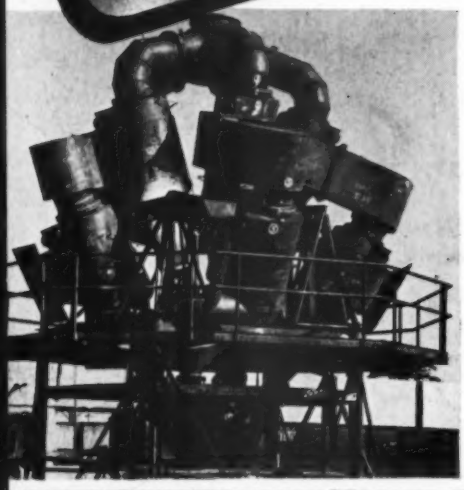
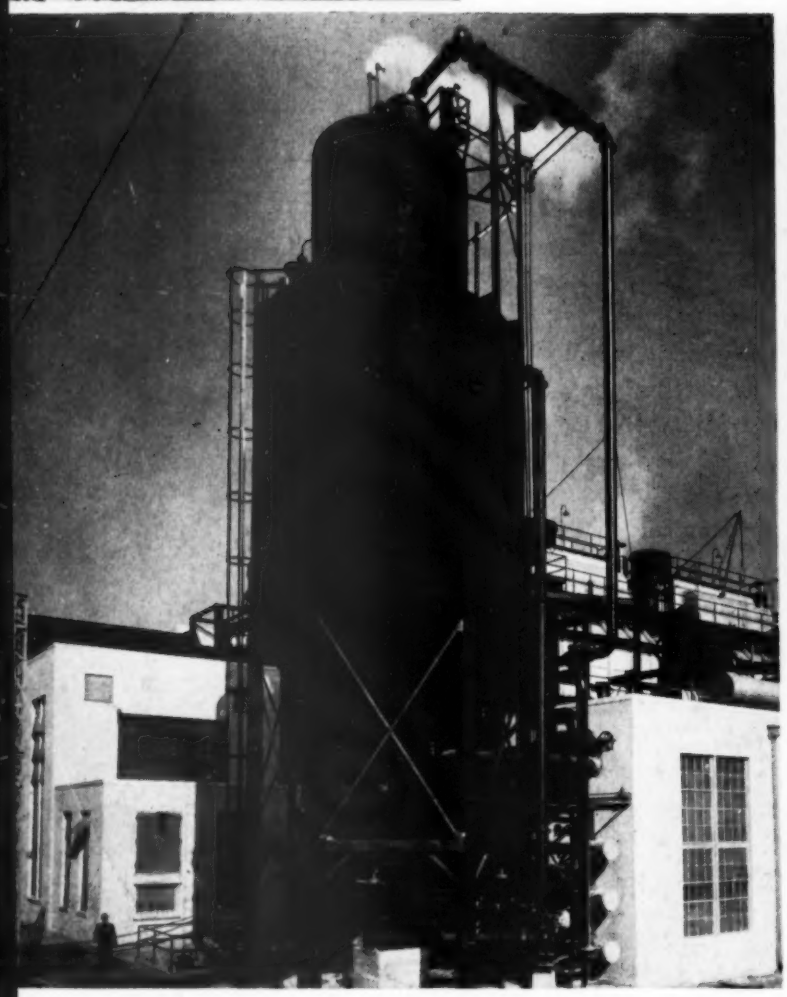
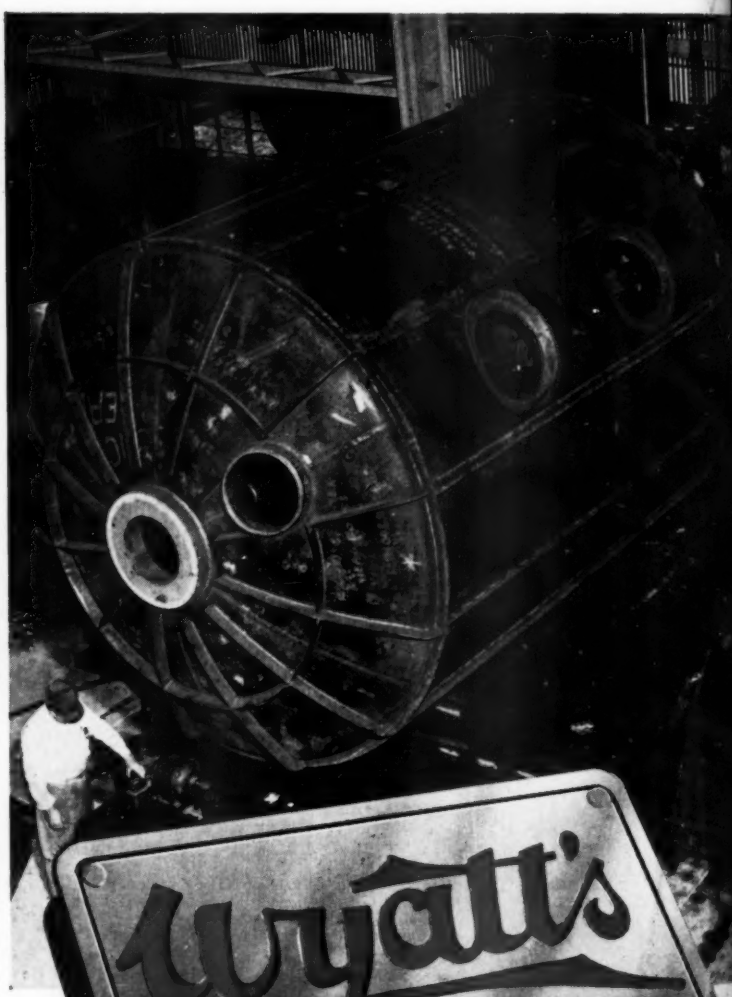




Above: Aluminum tanks. Left: Buell van Tongeren catalyst collector. Lower left: Water softening equipment. Lower right: Rotating drum for rice processing.





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